METALLURGIA

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INCORPORATING "THE METALLURGICAL ENGINEER".

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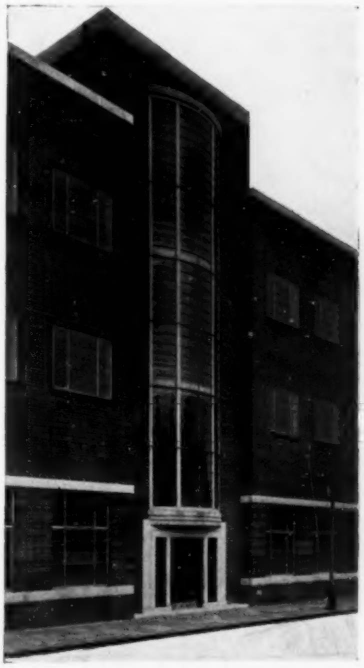
# Research and Technical Service

## The New Research Laboratory of The Mond Nickel Co.

*This new laboratory has been built and equipped to replace the previous accommodation which had become inadequate to the demand for more exact data and for improved alloys in keeping with engineering progress. Its function is to seek products which others can produce and to expand the use of nickel on a sound scientific and technical foundation.*



*The main entrance to the research laboratory.*

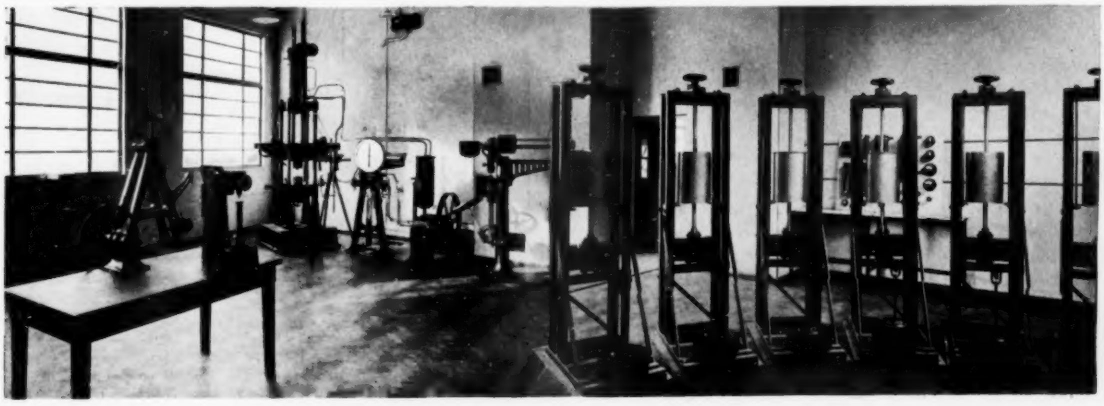
IT is somewhat unusual for a large research laboratory to be built and equipped with the primary object of seeking products which others can produce, yet this is the function of the new research laboratory of The Mond Nickel Co., which was recently officially opened by Lord Weir, who is a director of the parent company, the International Nickel Co., of Canada, Ltd. This laboratory is part of Mond Nickel's Research and Development Department; it has been built and equipped to replace previous accommodation which had become inadequate to the demand for more exact data and for improved alloys in keeping with engineering progress.

Research on the uses, as distinct from the production, of nickel has been proved an essential part of this Company's activities and has rendered nickel an important component of a wide variety of alloys, finding application in nearly every industry. This new laboratory has been built in order to extend the facilities for this type of research and thus to meet the increasing demand for alloys with special and outstanding characteristics occasioned by the increasingly severe requirements of modern industrial and engineering practice. The information gained as a result will be freely placed at the disposal of industry, and its application to the solution of industrial problems will be assisted by the Development Section. This laboratory, which is working with parallel laboratories, is thus supported by technical service to serve industry and, incidentally, to expand the commercial use of nickel on a sound scientific and technical foundation.

Research and technical service combined have proved fundamentals to progress in the case of nickel as formerly the use of this element was confined almost wholly to armament manufacture, but, since the Great War, the development of peace time applications, as a result of the policy of the producers of nickel, has made remarkable progress, and this despite the fact that manufacturers of both ferrous and non-ferrous alloys are constantly seeking, by means of research, to reduce the cost of their products, without reducing their properties, by reducing, or entirely eliminating, the use of nickel. So great is the progress in its application during recent years that, in many branches of industrial and engineering practice, nickel is regarded as an essential material.

Nickel is used by a wide variety of industries, and may be a component of alloys of such widely different characteristics

*The mechanical testing laboratory showing the creep-testing unit.*

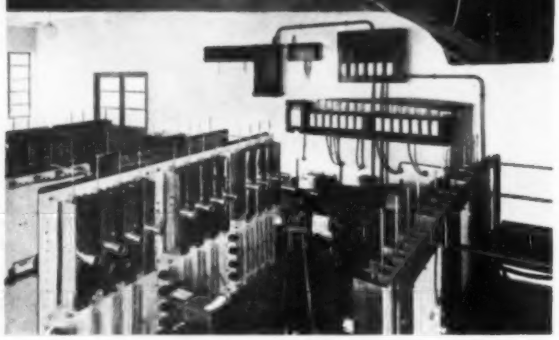


as good mechanical properties, malleability, corrosion-resistance, optimum magnetic properties, constant co-efficients of expansion or electrical resistance, susceptibility to heat treatment, etc., that special consideration had to be given to the design of the laboratory and to the choice of equipment, in order to ensure a sufficient degree of flexibility.

### The Laboratory

The laboratory is situated at Wiggin Street, Birmingham, on a site 187 ft. by 43 ft. In addition to a basement which provides accommodation for storage, the air-conditioning

*The metallography room.*



*Heat-resisting materials laboratory.*

plant, the service distribution gear, air compressor, etc., there are three floors. The ground floor space is divided into stores, machine shop, mechanical testing laboratory, heat-treatment laboratory, thermal analysis laboratory, weighing room, melting shop, and semi-technical laboratory. On the first floor are the physical and general laboratories, the metallography, preparation, macro-photography, and dark rooms. On the second floor are rooms arranged for the testing of electrical resistance and heat-resisting materials, chemical and corrosion laboratories. The roof of the building is flat and carries corrosion frames for carrying out atmospheric-corrosion tests. The staircase is circular and the floor of the entrance hall, treads and risers of the stairs are finished in ivory-coloured terrazzo, the walls being lined in black terrazzo divided into panels by strips of nickel silver embedded and ground flush. The balustrade is constructed from 20% nickel silver extruded sections.

### Equipment

The mechanical-testing laboratory contains a 50-ton Amsler universal testing machine and two Avery tensile-testing machines of 5 tons and 1 ton capacity, respectively. This laboratory also contains six creep-testing units, and a number of fatigue testing, hardness testing, and other machines. Provision has been made so that the portion of the room occupied by the creep-testing machines can be partitioned off later.

In the heat-treatment laboratory there are two Birlec electric furnaces, having hearths 24 in. × 12 in. × 18 in. and 18 in. × 9 in. × 6 in., two large gas-fired furnaces, and a number of small furnaces. Water- and oil-quenching tanks on castors are provided. The control panels for the heat-treatment furnaces are placed in the adjacent thermal analysis laboratory. These panels consist of temperature controllers, temperature recorders, and time switches. Connections between the furnaces and the controllers are facilitated by holes left in the floors and by wood strips cast into the ceiling of the basement. In the thermal-analysis laboratory are a number of potentiometers, a gradient furnace which can be raised and lowered by a small electric motor, and a special thermocouple-calibrating furnace. The room also contains a number of small electric furnaces, designed for thermal analysis.

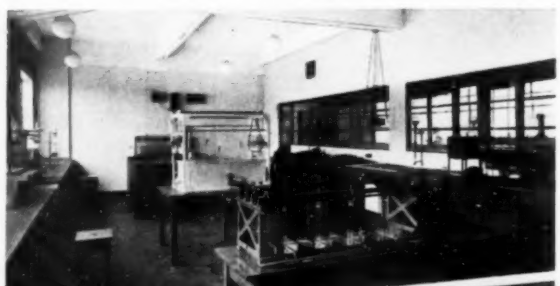
Near the heat-treatment laboratory is a large laboratory which has been designed to accommodate equipment for experiments on a semi-works scale. At present a corner of this laboratory is used for melting operations. There is a furnace pit containing a 40-lb. gas-fired furnace with space for two additional furnaces. There is also an 18-lb. capacity high-frequency electric furnace, and a casting pit.

The physical laboratory contains a Hughes permeameter and other magnetic-testing equipment, a variety of resistance bridges, and similar equipment for determinations of physical constants. The general laboratory adjacent is primarily intended for experimental work of a special nature which cannot be carried out in the ground floor laboratories, as for example, the determination of the effects of gases on metals, under conditions of precise control.

The metallography room contains a Zeiss photomicrographic outfit, and hand microscopes, together with a Hilger spectograph and a Leitz universal dilatometer. These last two instruments are located in the metallography room to keep together all photographic work. The preparation room adjoining contains the usual grinding and wet-polishing equipment, while beneath a hood there is a lead-covered bench with sinks. A fan is provided for the removal of fumes. The macro-photography room contains cameras, adjustable stands, spot lights and enlarger, and in addition is provided with normal dark-room facilities. For routine work there are two small dark rooms reached by a single-maze entrance ; the first room is used for printing and the second for the development of plates.

The testing of electrical-resistance and heat-resisting materials is carried out by the accelerated life testing of

*The main corrosion laboratory.*



*A small corrosion laboratory.*

resistance wires, for which there are 60 units for the Basch and Harsch test, and 60 units for testing wires in the form of spirals in refractory formers. Power is obtained from tapped transformers giving voltages from 5–110, controlled by two voltage regulators. Tests made include life tests on electric firebars, hot plates, oven and iron elements. For these latter tests there is a tapped transformer, giving

voltages from 5–250. Timing devices, relays and contactors are installed so that the elements under test may be switched on and off automatically, and equipment is provided to record the life of the materials under test.

The main corrosion laboratory contains specially designed apparatus for alternate immersion, circular path and jet tests. There are two rooms near the main corrosion laboratory, one of which is used mainly for corrosion tests involving the development of fumes, while the other is used for chemical analysis. Electro-plating is carried on at present in this section of the laboratory. A balance room, chemical stores and preparation room are located conveniently near the chemical and corrosion laboratories, while a small room is provided for indoor atmospheric corrosion tests.

The Manager of the Research and Development Department is Mr. W. T. Griffiths, M.Sc., F.Inst.P., F.I.C., and the Assistant-Manager, in charge of the Laboratory, is Dr. L. B. Pfeil, A.R.S.M., under whom it is confidently expected investigations will provide a great deal of valuable information, to metallurgical, engineering and chemical sciences as a whole.

# Malleable Cast Iron—Past, Present, and Future

*There is an ever-increasing demand in every sphere of modern life for small castings, for which malleable cast iron is eminently suitable, the essential requirements being cheapness, uniformity of quality, size, hardness, appearance and durability. In a recent paper, before the Staffordshire Iron and Steel Institute, Mr. C. Hubert Plant discussed the development of this industry and its future trends, a summary of which is given in this article.*

AT the beginning of the eighteenth century the iron and steel industry was still in a very primitive condition. Practically three kinds of iron were known to the industrial world: wrought iron, cast iron and crucible or cementation steel. Although ironfounding was an established industry, the need was felt for a metal which could be cast and which would be malleable when finished. About the year 1722, Reaumur, a French chemist, published a treatise which described a new method of obtaining malleable castings by means of heating iron castings, in conjunction with powdered hæmatite ore, for several days at a bright red heat. He did not necessarily discover this method, but this is the first publication on the subject, and he must therefore be given the credit of introducing malleable cast iron to the world. However, little or nothing was done with the new process for fifty or sixty years, until a Sheffield ironfounder, Samuel Lucas, began experimenting with Reaumur's ideas, and on May 30, 1804, was granted a patent No. 2767, from which it appears that he packed castings in iron ore or metallic oxides for some days, as in Reaumur's practice. This patent created practically no interest, until his brother, in 1831, obtained permission to use the patent, and commenced manufacturing cast cutlery. He was successful in this, and from that time onwards a few general castings were also made from this, or a similar process. The output was small, however, and ironfounders experienced considerable difficulty in dealing with castings other than those of very thin section, as the annealing proved to be such a delicate operation.

The next step in the history of malleable cast iron occurred in the year 1826, when Seth Boyden, a Bilston man who had emigrated to America, and who was carrying on the business of an ironfounder in Newark, New Jersey, commenced to experiment with Reaumur's idea. His experiments lasted from July, 1826, until September, 1832. He never obtained what he was striving for, because he was endeavouring to obtain white-heart malleable cast iron with American pig iron, which was low in silicon and high in manganese. Instead he obtained what has always since been termed American black-heart iron. It was quickly realised that Boyden had opened up immense possibilities, and the present American malleable cast iron industry has grown as a result of his experiments. So important was his work considered that a statue has been erected in Newark in commemoration of the man who laid the foundation of the industry.

Once commenced, the industry continued to thrive. In 1872 Alfred Hammer began to study the metallurgy of black-heart malleable cast iron, and in 1875 established the first laboratory entirely given up to the investigation of this material. He was the first metallurgist to bring the process down to a definite metallurgical operation.

During this time and up to the year 1880 little interest was shown by metallurgists in the industry, and those engaged in it were particular not to divulge what they considered as secrets, so that the industry was in danger of complete cessation. In 1880, however, probably due to the formation of Ley's Malleable Casting Co., which commenced to operate on the American principle, the industry began to revive, and by 1908, the industry was much more flourishing.

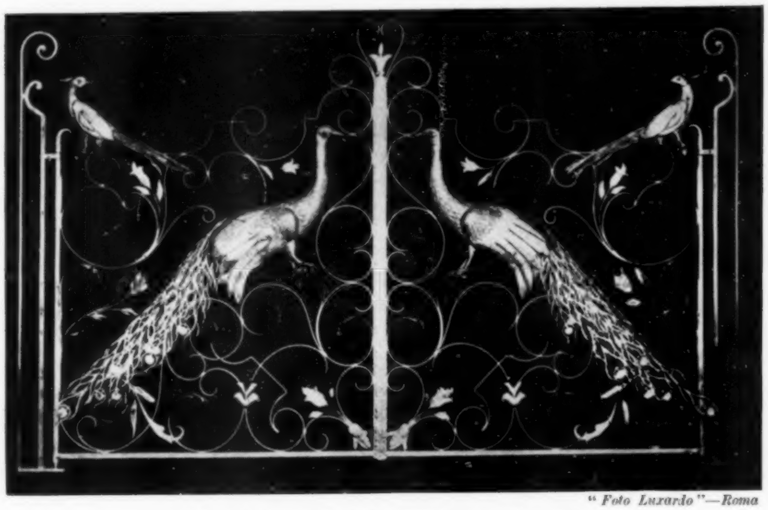
The general method of melting for black-heart castings was the air furnace, but none of the modern methods of melting had then been heard of. From 1907 until 1914, the industry was in a happy position. A large number of small foundries were running on rule-of-thumb methods, and a few moderately large foundries were making black-heart castings. During this period the white-heart makers made little attempt to improve their product, while considerable research work was being done in America and to a lesser extent in this country on black-heart malleable cast iron. The period of depression, from 1921 until 1932–33, however, forced the white-heart founders to consider the desirability of some standard other than that they had hitherto used. The secretive attitude was to some extent broken down, so that more began to be known. The black-heart founders were however able, due to knowledge gained previously, to produce economically, and it is only recently that the white-heart founder has been able to enter the field again in easy competition with their black-heart competitors.

The main direction in which white-heart founders have reduced costs and altered their method of melting is in the introduction of scrap steel, which comprises 25–30% of the metal charged, the remainder of the charge being mottled pig iron, or high-silicon grey hæmatite pig and white pig iron. This requires much more care in melting, and has resulted in the use of the rotary type of melting furnace, such as the Brackelsburg furnace, which is becoming more popular in this country, and very popular in the United States and Germany. The melting practice of black-heart castings has not varied much in late years, as regards the metal used, but the most popular types of furnace are the air furnace and rotary furnace. The electric furnace is also used, but generally as a means of refining iron previously melted in the cupola. This process of duplexing is also carried out by melting first in the cupola and by the use of a rotary furnace for super-heating and refining.

Black-heart iron, in the future, appears likely to alter very much from the original type introduced by Seth Boyden. The tendency now is to produce pearlitic malleable cast iron, which will produce tensile strengths of as much as 50 tons per sq. in. with elongations up to 24%. If these irons are competitive in price, it appears that there will be a big market for them.

# Aluminium——A Decorative Medium

*Aluminium is an ideal medium for the smith's art. It is light and lustrous, resembling silver in many ways, it can be beaten very thin or tooled delicately, and the fact that it is not subject to corrosion recommends it as a decorative metal.*



"Foto Luxardo"—Roma

*Aluminium gate with peacocks and pheasants. Height 47¼ ins. and width 74¾ ins.*

In ancient times, when all objects of utility, as well as adornment, were marked with a desire for beauty, when the most frequently used meat jack was regarded not only as a thing of use, but also as something that might be made beautiful, bronze- and iron-work flourished in all their excellence. Almost since their very inception the use of these materials has been applied to architectural and decorative work, and although not many of the earlier examples of craftsmanship with these materials are now in existence, there is sufficient evidence to indicate that the quality of craftsmanship in those days was of a very high order.

The art of the metal worker fostered in these early days continues to be manifest in modern design and architecture, but gradually new decorative mediums have been introduced. Formerly copper, bronze and iron predominated, but gradually various copper and iron alloys were found to be useful mediums in the hands of expert craftsmen and excellent examples of artistic work in these materials are well known. Recently, however, aluminium has come to be regarded as a worthy addition to the range of metals which in the hands of the expert can be transformed into a thing of unsurpassing beauty.

The advantages of aluminium for architectural purposes has long been recognised and during recent years its application for gates, grilles, balustrades, handrailing, panels, columns, lamps, and in part for all kinds of ornamental work, has made great progress. The natural finish is very pleasing, it is light and lustrous, resembling silver in many ways, and the fact that it is not subject to corrosion or excessive tarnishing recommends it as a decorative material. Aluminium is capable of almost as refined treatments as silver; varying degrees and types of finish can be obtained by sand-blasting, scratch-brushing, and dipping in caustic soda and nitric acid to give a frosted finish, but the anodic process is now more widely used, by which it is possible to obtain a range of colour and tones which will harmonise with any desired decorative scheme.

*Acanthus light bracket. Height 21½ in.*

"Foto Luxardo" — Roma

*Gate with horses. Height 51 ins. and width 73¼ ins.*

"Foto Luxardo" — Roma

For architectural purposes aluminium is easily worked and jointed, and for such purposes a wide range of extruded sections are available. But recently it has been shown that aluminium is an excellent medium for hand-wrought work. As the accompanying illustrations show, aluminium can be worked into the most beautiful forms. The gates shown are by Coletti, the Italian master smith, and formed part of an exhibit in New York. The sympathetic manner in which the medium has been treated, together with the technical skill displayed in the execution, makes them an unusual example of what a skilled craftsman can do. Each part is delicately chiselled, twisted and hammered to its required form and then welded to its companion unit. This welding process, incidentally, requires expert knowledge and craftsmanship, because there is a narrow zone of temperature required; below it the weld is not achieved; above it the parts suddenly melt.

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# Easing Control Restrictions to Satisfy Needs of Industrial Activity

THE progressive spirit which continues to permeate British trade and industry is reflected in the gradual increase in production. Manufacturers have made vast strides in developing efficiency and can take credit for contributing towards the expansion of trade now being experienced. Practically all sections of industry are participating in the recovery which has been growing with increasing momentum since a revival began to be manifest last year. Doubtless a number of disquieting factors connected with international politics have, to some extent, been responsible for increased industrial activity, but it will be realised that the improved trade now being experienced is having a very considerable influence on its development. Actually signs of a boom are beginning to appear and, while there may be differences of opinion as to whether the circumstances are such as to regard it as a healthy sign, in view of the heavy call for armaments unemployment has fallen, particularly in districts outside the distressed areas, and there is a shortage of a certain type of skilled workers. Even in the distressed areas the results of improved trade are having a beneficial effect.

Recovery, however, is not confined to this country, it is general and with improved conditions import duties, quotas and other forms of restriction are presenting problems which call for more frequent adjustment. The task of reconstruction, which was of vital importance to the economic welfare of this country, necessitated protection against severe competition, but while this policy is admirable during a period of depression or to give industry a reasonable opportunity to execute schemes to promote more efficient production, the needs of industry may be such as to warrant a substantial modification in order that its requirements can be met. During recent months the demand for materials for constructional purposes has been so great that the problem of obtaining adequate supplies has become serious. This is especially true with regard to certain grades of steel.

In our last issue we stated that a definite shortage in some grades of steel exists and the position is becoming so acute that negotiations are in progress with a view to a further increase in the import quota of semi-finished steel from Continental producers. This despite the fact that each successive month the steel industry in this country establishes a new production record. The figures for October, for instance, show a production of 1,060,500 tons, which is the highest the British industry has experienced. During the past 10 months the total production has reached 9,677,700 tons, an increase of 18% as compared with 1935. The industry is now working to effective capacity and further increases in output depend upon new extensions and new plant coming into production. But the strength and persistence of the demand for steel, which is a striking feature of the present industrial activity, remains. In order to meet the demand it has been found necessary to increase the quantity of steel imported and, to effect some control over these imports, a system of import licences has been instituted.

The scheme has now been put into operation whereby certain prescribed quantities of iron and steel products of particular classes can be imported on payment of a duty of 20%. To qualify for admission at this rate of duty, consignments must be accompanied by a quota certificate and a certificate of origin. Goods of the classes affected, which are unaccompanied with valid certificates will be charged special rates of duty, corresponding practically to those imposed in March last year. In some instances the scale will run up to 50%.

For the present the total quantities authorised for each country will not exceed the imports from that country in 1934. Shipments in excess of these amounts will pay the full special scale. Licences are issued to the responsible iron and steel organisations in Belgium, Luxembourg, France, Germany and Sweden. The first four countries are parties to the International Steel Cartel Agreement. Sweden being still outside that arrangement. All five countries however, have national trade organisations which will distribute licences to the concerns actually shipping the iron and steel requirements. In the case of other countries, quota certificates will be issued by the Board of Trade, and certificates of origin by a British Consul, by a Chamber of Commerce, or by some person approved by the Board of Trade.

The products covered by the new regulations are the semi-finished categories of ingots, blooms, billets and slabs, heavy sections, such as girders, beams, joists and pillars, rolled forms, such as angles, shapes, sections, bars and rods, flat products, such as plates and sheets, hoop and strip and wire goods, such as wire, wire springs, wire netting, nails and staples. Rails are also included.

The arrangement refers only to steel products; pig iron is not included because the main imports of this material come from British India, which enter United Kingdom ports duty free, according to the terms of the Ottawa Agreement. During the first nine months of this year 95,000 tons of pig iron have been imported from India. In addition, large shipments from Russia have been imported by special arrangement. During the period mentioned the pig iron imported from this source reached 78,000 tons in comparison with 17,000 tons during the whole of 1935.

Special and high grade steels are not affected by this arrangement because they are either outside the quota scheme altogether or they are above the upper price limit, such as most of the Swedish steel trade. Steel imports from foreign countries, during 1934, other than those bound by the International Steel Cartel Agreement, totalled about 112,000 tons, more than half of which came from Sweden. Included in this total are about 85,000 tons of products outside the ranges affected by the new regulations, leaving a relatively small tonnage of steel goods within the range subject to quotas which may be imported at the reduced import duty, but obviously larger quantities may be authorised if the demand continues to be acute.

Doubtless many will say that the demands of the consuming industries call for an expansion of the iron and steel industry's capacity and, while a strong case can be made for the building of new plants, if they represent technical advances and reduce the general cost of production of steel, there is nothing to indicate that this is other than a peak demand due to expansion resulting from a rearmament programme. Apparently it is assumed that the demands are abnormal and imports are being used only to supply

the amount of steel which exceeds the capacity of the plants in operation in this country.

While the demand for steel is exceptional and consumers of this material may be regarded as enjoying boom conditions, the same conditions are affecting the imports of other raw materials consumed by the same industries. Thus the demand for non-ferrous materials has necessitated considerable modifications to production agreements to satisfy requirements. The circumstances are somewhat different with these materials since practically all the non-ferrous metals consumed are imported in one form or another. Consumers are buying on a more optimistic scale than for some years past; with the result that prices tend to rise. The copper market for instance, has shown remarkable strength of late and the price level has risen by well over £2 per ton. In comparison with the price levels reached in 1929, however, copper may be regarded as cheap, but conditions on the production side have changed considerably since that time; production in the United States has declined, while production in Canada and Northern Rhodesia has increased, and although prices will tend to rise it is doubtful whether they will exceed £40 per long ton, because it would be better for profitable mines to increase production at a lower price than to cause the opening of less productive mines by forcing up the price.

It has been found necessary to increase tin production quotas and, while prices tend to rise, control arrangements should guard against rapid fluctuations. With practically all the base metals it has been necessary to reinforce distribution systems to meet the increasing demand. The strength and persistence of the demand for steel and non-ferrous metals is a striking feature of the present industrial activity, and the easing of control restrictions will not only assist consumers in obtaining supplies but will reduce the possibility of sharp fluctuations in price.

## Transportation into Yukon Mining Areas

Plans have been arranged by the Dominion Government for an expenditure of $66,000 as an aid to the improvement of transportation facilities into mining areas in Yukon and the Northwest Territories. Part of the amount will be used in improving navigation facilities into the Lake Athabaska goldfield. The expenditure is an allocation from the $1,500,000 provided by the Government for similar purposes in mining areas throughout Canada.

In the Klondike district assistance is being given to the completion of a new road into Sulphur Creek, and to the improvement of a trunk road into the middle section of Dominion Creek. Both of these roads will serve placer areas being aggressively developed by the Yukon Consolidated Gold Corporation. The Company is erecting a new camp at the mouth of Sulphur Creek, and is stripping and thawing ground along the creek in preparation for the operation of new dredges.

In response to a request from aerial transportation companies, funds are being provided to assist in the erection of a winter aeroplane landing at Fort Resolution, an important mail and traffic point for incoming and outgoing planes. Traffic into the Outpost Island mining field, and into the Yellowknife river area will be aided by the installation of navigation lights across Great Slave Lake. Provision is made also for the protection of the water front at Fort Smith and for the establishment of wharfage facilities at that point, and at other points along the Mackenzie river system. With these improvements the necessary facilities will be provided to assure the safe and ready passage of the steadily increasing volume of freight being handled along the route.

The Minister of Mines at Ottawa has expressed satisfaction with the progress being made under the Government's scheme of assistance in improving transportation facilities into mining areas. Projects are under way in the several provinces that have signed the agreements. Under the scheme the Dominion Government contributes on a two to one basis with the provinces.

# Forthcoming Meeting

### INSTITUTE OF METALS

BIRMINGHAM SECTION

Dec. 3. "Some Aspects of Industrial Hygiene," by Howard E. Collier, M.C., M.B., Ch.B.

Dec. 15. "Metallurgical Problems in the Chemical Industry," by N. P. Inglis, D.Sc.

LONDON SECTION

Dec. 2. "Some Impressions of Industry in the U.S.S.R.," by W. T. Griffiths, M.Sc.

NORTH-EAST COAST SECTION

Nov. 27. "Refractories," by J. W. Mellor, D.Sc.

SCOTTISH SECTION

Dec. 14. "Metal Spraying by the Wire Process," by W. E. Ballard.

SHEFFIELD SECTION

Dec. 11. "Wrought Nickel Silver Alloys," by M. Cook, M.Sc., Ph.D.

SWANSEA SECTION

Dec. 8. Film Display of Metallurgical Interest.

MANCHESTER METALLURGICAL SOCIETY

Nov. 18. "Discussion on Microscopy," opened by J. Dickson Hannah, M.Sc., F.I.C.

Dec. 2. "Modern Welding," by W. Andrews.

### INSTITUTE OF BRITISH FOUNDRYMEN

BIRMINGHAM BRANCH

Dec. 4. "Bronze Castings," by E. J. L. Howard.

EAST MIDLANDS BRANCH

Nov. 28. "More Non-Ferrous Problems," by F. Dunleavy

Dec. 12. "Patterns and their Relation to Moulding Problems," by S. A. Horton.

LANCASHIRE BRANCH

Dec. 5. "Developments in the Production of Ingot Mould Castings," by R. Ballantine.

BURNLEY SECTION

Dec. 8. "The Melting of Steel in Small Foundries," by Dr. E. Gregory, M.Sc., F.I.C.

LONDON BRANCH

Dec. 2. Joint Meeting with the London Section of the Institute of Metals. "Some Impressions of Industry in the U.S.S.R.," by W. T. Griffiths, M.Sc.

Dec. 11. Annual Dinner.

EAST ANGLICAN SECTION

Dec. 3. "Some Simple Founding Principles," by A. J. Richman.

MIDDLESBROUGH BRANCH

Nov. 20. Works Visit to the Centrifugal Cast-Pipe Foundry of Messrs. Cochranes (Middlesbrough) Foundry, Ltd.

NEWCASTLE-ON-TYNE BRANCH

Nov. 21. "Estimating for the Foundry," by C. M. White.

SCOTTISH BRANCH

Dec. 12. "Mould and Core Drying," by W. H. Smith. Annual Dinner.

FALKIRK SECTION

Nov. 21. "Design, Patternmaking and Moulding, and their Relationship to Producing Castings Competitively," by M. Russell.

SHEFFIELD BRANCH

Dec. 3. "The Planning and Progress of Foundry Operations," by Commander Trevor Glenny.

### INSTITUTE OF MARINE ENGINEERS

Dec. 8. "Engines Aft v. Amidships," by John L. Scott, M.Sc.

### INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Dec. 1. "Construction of Two Welded Oil Tankers," by E. R. Macmillan.

## Personal

Mr. E. H. Siddall, of Ruston and Hornsby, Ltd., has been appointed manager of their Dublin branch, in succession to Mr. T. C. Ives. For many years Mr. Siddall has been attached to this Company's Glasgow branch.

Mr. Ives, who has been connected with this Company for 36 years, is leaving Ireland at his own request, but is retaining his connection with the Company.

# Casting Non-Ferrous Billets

By GILBERT EVANS

*The object of the caster is to produce billets with a perfect surface and free from porosity, and work in the research section of a factory is directed to this end. In this article the author describes, as a result of personal experience and observation, methods adopted by various British and Continental concerns and emphasises many important aspects.*

THE application of the results of many investigations carried out in recent years has facilitated the work of the non-ferrous billet caster, who is now able to produce billets possessing a more perfect surface with greater freedom from porosity, but in one direction, in particular, this country has lagged behind American and Continental practice until fairly recently and that is in the adoption of moulds of the water-cooled type for all classes of work subsequently submitted to rolling, extrusion and drawing processes. Prevailing practice, especially in America and Germany has been closely watched in recent years, and in this country the eclipse of the cast-iron moulds, generally in use, has been foreshadowed for the past few years.

Another aspect of production against which producers in America, for instance, frequently comment unfavourably on British practice is the continued use of the reverberatory type of furnace for the casting of billets to be used in tube manufacture. The development of electric furnaces in that country resulted in the complete elimination of the reverberatory furnace, for this purpose, many years ago.

It is an indisputable fact that by the combined use of the electric furnace and water-jacketed moulds, a higher degree of excellence has been attained in the surface and texture of metal alloys. To give one example which the author experienced in casting billets of various alloys in C.I. moulds: it was customary to bore the moulds to a diameter greater than that of the container of the extrusion press, and " lathe turn the billets " down to size, a treatment necessary to remove surface defects, most of which are directly traceable to the working conditions and equipment of the casting shop.

The adoption of the copper-lined water-cooled mould has to a great extent made the expensive surface turning unnecessary. It was a wise policy on the part of our metallurgical staffs to stay their decisions, until continued development had resulted in the high state of efficiency in methods and application, now prevailing, had been demonstrated, a shrewdness which is reflected by the reputation for quality and finish ultimately attained. It was recognised that all classes of copper were not suitable for lining water-cooled moulds and that the presence of 0·4% arsenic lowers the thermal conductivity of the mould by 50%.

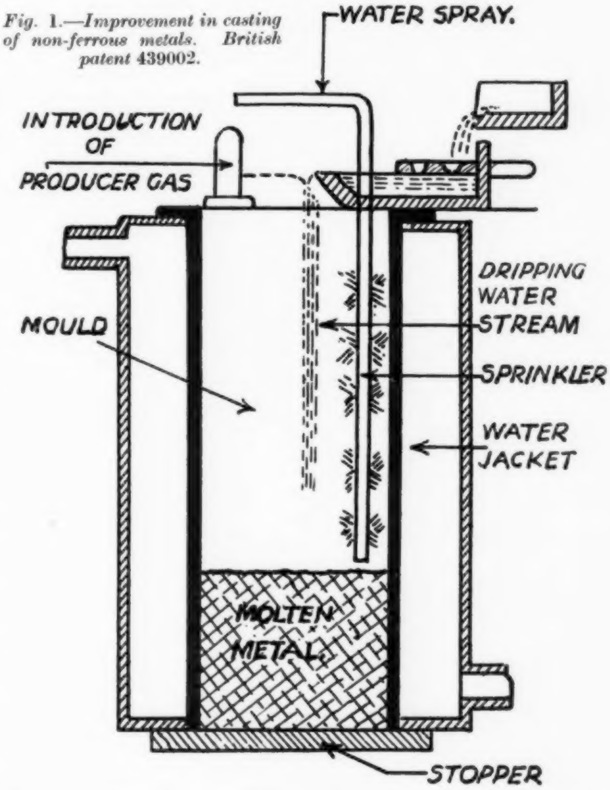
In a recent investigation at the Research Department, Woolwich, Bailey,[1] the subject of mould material was studied, and his deductions of the results are of interest. Grey cast iron, he states, is the material most generally used for the moulds for the casting of non-ferrous strip ingots. Such moulds are subject to two peculiar defects: (*a*) gas evolution from the face of the mould when this is overheated during pouring (" blowing "); and (*b*) transverse cracking of the working faces. The conditions producing " blowing " were studied and the gases found to originate in a reaction between the carbon of the iron and a superficial oxide film. Transverse cracking of the cast-iron mould surface was found to be due to stresses resulting from a high temperature gradient in the mould wall immediately after casting. Mild-steel moulds, which are free from " blowing " and cracking, were found to be liable to serious distortion resulting from such stresses. After investigations copper was considered to be the most satisfactory material for strip-ingot moulds. Its high thermal conductivity prevents serious temperature gradients and consequent distortion. For high-melting-point materials copper moulds are water cooled with advantage, but for alloys such as brass they can be used under certain conditions without any special cooling.

It is noteworthy that Junker's copper-lined moulds were first introduced in this country about 1926.

### Temperature and Treatment of Poured Metal

Correct pouring or teeming temperature is of chief importance in obtaining reliable solid metal and in modern castings shops the use of the pyrometer is no longer viewed as a nuisance by the workmen. Up to the time of its general

*Fig. 1.—Improvement in casting of non-ferrous metals. British patent* 439002.




adoption, the caster was the sole judge of the condition of the metal in the crucible. One recollects that in the case of teeming copper for piercing in the rotary mill, it was considered to have reached perfection on the appearance of " cat's eye " following the stirring in of the flux. The term as applied was quite a justifiable one, at all events little trouble was experienced when the solid round billets were subjected to the severe torsional stresses set up in the rotary type of mill. With the pyrometer in regular use it is not uncommon to find one employee responsible for the use of this valuable addition to the foundry's equipment, and his decision as to fitness for pouring is unquestioned, so relieving the caster of any degree of guesswork. Its use also eliminates the necessity of allowing only special men to have the responsibility for certain alloy mixtures. There are temperatures varying from 1,100° C., in the case of copper, to 1,350–1,400° C., in the case of cupro nickel, at which the molten metal is at its best, so definite limits are set in accordance with the composition.

[1] G. L. Bailey, M.Sc., *Jour. of Inst. of Metals*, 1932, p. 203.

Interest is attached to a method adopted in America used in connection with the casting of billets for extrusion into tubes. It refers to practice at the Wolverine Tube Co., U.S.A., first mention of which was made in December, 1935. In this method water jacketed moulds are used and water is allowed to drip into the mould being poured at the rate of approximately 100 c.c. per min. It is asserted that the water tends to draw the carbonised-mould dressing to the centre and top of the rising column of molten metal, as well as to form a steam blanket over it which reduces oxidation to a minimum, with the result that a clean non-porous billet is produced. Incidentally, unless phosphorus is maintained in the molten metal, the addition of water will result in an explosion. Further interest is created by studying British patent 439002, Fig. 1, which is credited to American Metal Co., Ltd., of New York. The principle is slightly different. In this it is stated that in casting deoxidised copper containing a small amount of phosphorous or other deoxidiser, the mould is coated with a film of water before pouring. The mould is preferably of the water-cooled type and is first dressed with the usual oil mixture. Water is preferably also added during casting, and may be allowed to form a pool on the molten metal in the mould. Producer gas, or other oxygen excluding gas, may also be introduced by a pipe. The water may be introduced in atomised form by the gas or steam or as spray by means of a pipe. During casting the water may be introduced in a stream. The last paragraph be it noted brings the application of water during teeming into line with practice at the Wolverine Tube Works.

### Teeming

Various opinions exist as to the best method of teeming molten metal into the moulds, and this is a detail which requires consideration. The advocates of quick teeming are many, but it is certain that there is a rising tendency in favour of the tundish method as shown in Fig. 2; the proportion of the delivery holes in the base of the dish equalling from 9–15% of the area of the billet, slab or ingot. The interior surface of the dish has a thin dressing applied to it before receiving the molten metal. In the case of open pouring the delivery angle should be such that as far as practicable the metal should not inpinge on the surface of the receiving chamber.

When melting alloys in crucible pots, the use of iron or steel rods for stirring was at one time common practice, but, since research work has become the rule, this menace has been eliminated by the introduction and insistence in the use of charcoal stirring sticks, which are of suitable length and attached to the end of a tube. Under the old conditions investigators traced many defects to the use of iron stirrers. The casting of wire bars in open moulds is preceded by a thin dressing being applied to the surface of the moulds which are also preheated to a temperature of 50–70° F.

### Control of Volume of Water

As illustrating the importance of attention to small details, the author was intrigued by an experience related to him by a charge hand in the employ of a large Continental concern. In the use of copper-lined moulds, these works regard the governing of the volume of water as a matter requiring experience, and in the instance referred to, the employee in charge of the valve or cock had been promoted. No proper instructions were given to the man who took over his job, and in consequence this apparently unimportant neglect led to a complaint concerning the surfaces of the cast billets and the omission of instruction was remedied.

### Care of Moulds

Cleanliness is an essential to the turning out of good work, and this necessity is specially applicable in the case of moulds, which includes the standard cast-iron billet mould, slab and ingot type as well as the water-cooled copper-lined type. The C.I. mould is liable to develop a kind of hardened surface when in continual use in which state it delivers billets, slabs, or ingots with a pimply and in some cases a " short " surface. At the first sign of these mechanical defects it is necessary to subject the moulds to an annealing heat-treatment prior to which all contact surfaces are subjected to scrubbing with a suitable wire brush, followed by an application of thick tar, which, in the following annealing, removes thoroughly all foreign substances and restores the working surface to a soft state. Excessive dressing is a cause of surface trouble, not so apparent as in the past, in view of the recognised fact that its chief object is to form a protective film between the surface of the metal being cast and the mould, and it should be applied intelligently and with this point borne in mind. In the case of common moulds for round billets used for piercing and/or extrusion, the body of the mould should be cooled down to hand heat between each cast. This

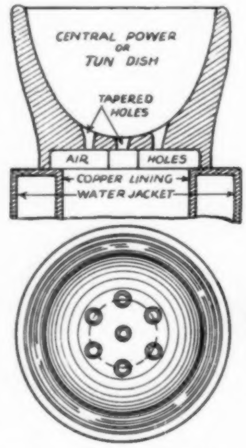



*Fig. 2.—Sketch showing principle of central pouring with central tundish.*

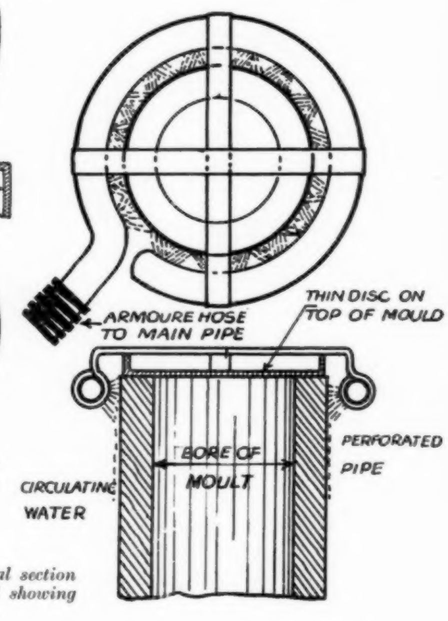



*Fig. 3.—Plan and vertical section of top of cannon mould showing method of cooling.*

disposal of heat is best done by using a sprinkler made of 1½ or 1¼ steel tube, which is perforated while straight by a number of $\frac{3}{16}$ or ¼-in. holes, and afterwards formed into a circle or ring about 2–3 in. larger at its inside diameter than the outside diameter of the mould. Suitable attachment is required at the top end to ensure equal sprinkling lengthwise over the mould, the open end of the mould bore being covered to prevent the water connecting with the interior. The extended end of the ring is connected by armoured hose to a T piece on the main water supply. Fig. 3.

The bore of the mould should be well scrubbed out between each cast using a ramrod made of copper trimmings or wire, Fig. 4, which should be a good scraping fit. Dressing of the same surface before pouring of metal is done by means of a ramrod made of coarse tow, after having been dipped into the bowl of dressing which is kept in a semi-fluid state by application of low heat. The dressing should be made anew every other day, and attention should be given to cleanliness with similar intensiveness as is required in other minor details, in fact duplicate containers are recommended. A dressing, evolved after extended experiments, which gave satisfaction is made up as per the following recipe: Three parts lard oil; 2 lb. of tallow; 1 lb. China clay; ½ lb. of French chalk, heated and stiffened to a treacly state by the addition of finely powdered charcoal.

### The Real Value of Dressings for Moulds

It is no exaggeration to state that until fairly recently the view held by the melter and pourer of non-ferrous metal into moulds, and also of his immediate departmental

foreman, was that the application of dressing to the mould surface was purely for the purpose of lubrication and to assist in easy extraction. This view is confirmed by the licence allowed to the charge hands, each of whom swore by his own particular dressing, some of which had been handed down from father to son. An illustration may be given where even in the fluxing of his metal the same latitude was given. The writer noticed one particular caster, every time he skimmed a pot, extract mysteriously from his waistcoat pocket something which he put into his metal just before teeming. It was after a promise of secrecy that ultimately he disclosed that the closely-guarded secret was a bit of " carbolic soap." Its particular effect on the quality of the metal could not be explained, but his father had used it and passed the information on for the benefit of his son. A metal caster's job has ever been a remunerative one, and up to the war promotion to such a responsible job was rare, it was a question of inheritance. As stated, each caster was allowed to make his own dressing, which was slapped on in a haphazard manner.

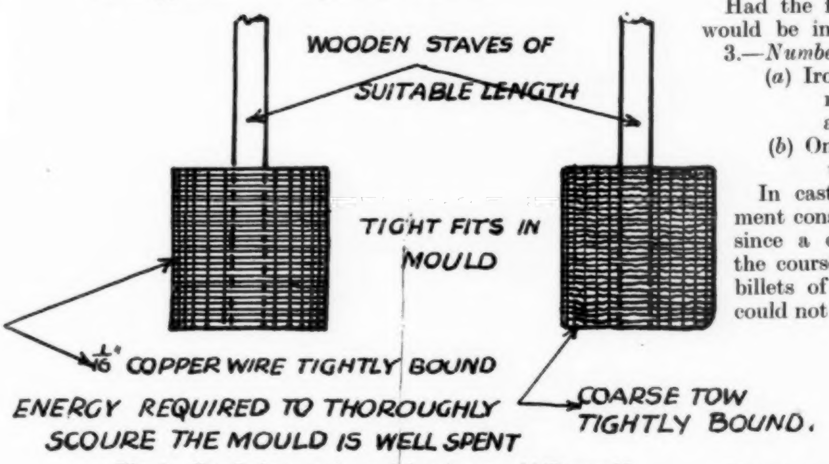



*Fig. 4.—Details for scraping and dressing round billet moulds.*

Where a number of casters were engaged on the same alloy, varying results led at last to research, to determine the cause, and ultimately it was definitely traced to individual dressings. This led to the standardising of dressings for various mixtures, a diversion intensely opposed by the casters, but the effect was justified by an all-round improvement and levelling up in quality. The present generation of casters realise that dressing properly applied forms a protective film between the ingot and the mould and is not solely a lubricant to make extraction easy. The secrecy surrounding the casters, heritage was rudely shattered in the early stages of the war, when there was such a demand for non-ferrous metal rods, bolts, etc., for such purposes as time bands, shell noses, driving bands and the like. Almost all assistants who were content with their jobs as ingot men and helpers were promoted to casters and given work at the extra pot fires which had become necessary. The reliable caster, however, still holds a high position in the estimation of the works management and the author would be prepared to accept his decision on suitable temperatures, where the ordinary mixtures are concerned, with the same reliance that one places on the registration of the pyrometer.

### A Comparison of Cannon-Type Cast-Iron and Water-cooled Moulds

While holding the opinion that the application of water-cooled moulds of the Junker and similar types, heralds the abolition of the long accepted standard C.I. moulds for the casting of non-ferrous metals, the writer is not in total agreement with the comparisons and deduction as to the merits of the water-cooled mould published in Germany. These deductions are given in the following notes, together with the writer's comments, resulting from extensive practice. In making comparisons it should be appreciated that the conclusions were based on ingot, slab and billet casting.

1.—*Length of life and replacement.*

(*a*) Using iron moulds: Maximum 1,000 casts, then compete replacement.

(*b*) Using water-cooled moulds: Practically no wear. Moulds in use in 1913 still at work. Copper lining is renewed after 3,000–5,000 casts. Sometimes 15,000 casts without renewal. Billet moulds have indefinite life.

The writer is not in agreement with the conclusion regarding C.I. moulds. As has been mentioned earlier in this article the application of tar and subsequent annealing remedied defects. When this failed the moulds may be rebored to next billet diameter—*e.g.*, one originally 5-in. bore could be rebored several times until finally discarded at 6½-in. bore.

2.—*Casting time from pan to extraction.*

(*a*) Iron moulds 20–30 min.

(*b*) Water-cooled moulds 2 min.

Had the first item been given as 5–8 min. the writer would be in agreement. Much depends upon cleaning.

3.—*Number of moulds and space required.*

(*a*) Iron moulds. Each casting unit requires 5–6 moulds on account of wearisome preparation and heating up.

(*b*) One water-cooled mould can serve several casting units.

In casting from a reverberatory furnace the equipment consists of several C.I. moulds of each diameter, since a charge of up to 15 tons must be poured in the course of 6–7 hours. Where a large number of billets of similar diameter, it is obvious the operator could not wait between each teeming.

4.—*Casting Speed for Continuous Work.*

(*a*) Iron mould every 2–3 hours, endless shifting by crane or turntable.

(*b*) Water-cooled mould every 5–10 min., the mould is always in pouring position.

This depends entirely on the arrangement of the casting pit and to the number of moulds available. The C.I. moulds necessary are placed in position and are sometimes in constant use for a week or more, especially the intermediate diameters 3–4 in.

5.—*Operators for a 300 k.g. casting unit.*

(*a*) Cast-iron moulds require three attendants.

(*b*) Water-cooled moulds 0·5 owing to easy management without lifting. The use of continuous moulds permits the use of all labour-saving devices. All parts of mould are only hand warm, on radiation; burns are impossible and there is no dust trouble. On the other hand C.I. moulds are often at red heat, and there is laborious scraping and chiselling of walls.

The writer can only assume that this statement is either very biased or due to lack of experience in dealing with charges of 15 tons and upwards. It is true that the services of three attendants are necessary, but these are spread over 20–30 moulds. In an experience extending over 30 years the writer has not seen a mould at red heat. A suitable water supply and adequate sprinklers obviate this. In the case of crucible casting, working with 5 or 6 fires, a set of four moulds is needed. A certain amount of scraping was at one time done on split moulds, an effect later traced to unsuitable dressing and quickly remedied. Little chiselling is necessary if a wire brush is used for fettling. Periodical annealing of the moulds is necessary in all cases and the surfaces treated as previously described.

6.—*Quality of cast slabs.*

(*a*) With iron moulds the structure of metal is unequal and quite beyond control.

(*b*) Water-cooled moulds provide a uniform structure and can be regulated as desired.

Working conditions being equal, the question of structure has already been mentioned and an adequate supply of

water applied in the manner previously suggested ensures economical life of C.I. moulds properly and periodically treated. In giving an opinion it is suggested the conditions in the casting shop when using C.I. moulds were lacking in supervision. The writer emphasises the fact that he is greatly in favour of water-cooled moulds, but as the originator of the standard specification to which C.I. moulds were made, believes that the comparison of the two methods is worthy of analysis.

# Reviews of Current Literature

## Aluminium Paint and Powder

Aluminium paste and powder are unique paint pigments. When mixed with a suitable varnish vehicle, they form paints having an unusually serviceable combination of properties such as high opacity, high reflectivity, low emissivity, high moisture proofing efficiency and great durability. Unlike most other pigments, aluminium powder does not need to be ground in oil, and in fact is usually injured by grinding. Stirring together of aluminium pigment and vehicle, to form a uniform suspension, is all that is required to prepare the paint for use. It can then be applied like other paints, either by brushing or spraying. With a suitably chosen vehicle, it can be applied generally on metal, wood, cement or concrete, brick, stone, etc., and is remarkable for the many specific applications it has.

Although aluminium powder in one form or other has been available for many years, the extent of its usefulness has not been realised until recent years. Research and development, quickened by the war, created the fundamental background of knowledge and experience on which is based the present extensive use of aluminium powder. It was as a result of this development that the first edition of this book was published some nine years ago. Since then, however, progress has been so rapid that the first edition is inadequate for the paint technologist of to-day. This new edition is, in fact, a new book and, even though it is more than double the length of the first edition, so much more recent technical information is made available that many subjects of interest are only briefly discussed.

This book is admirably prepared, well illustrated, and provides a mine of information on aluminium powder production and application. It will be of special value to the paint technologist and in its particular field may be regarded as a standard work of reference.

By JUNIUS D. EDWARDS; published by the Reinhold Publishing Corporation, 330, West Forty Second Street, New York, U.S.A. Sole British agents are Chapman and Hall, Ltd., Henrietta Street, Covent Garden, London, W.C. 2. Price, 22/6 net.

## Transaction A.I.M.E. (1936) Vol. 120

### Iron and Steel Division

THIS volume contains papers and discussions presented before the Iron and Steel Division A.I.M.E. at the meetings held at Chicago in October last year, and at New York in February this year. There are 19 papers, including the Howe Memorial Lecture, by H. F. Moore, on "Correlation Between Metallography and Mechanical Testing."

The presentation in one volume of papers embracing both the fundamental science and the application of fundamentals to the solution of practical problems admirably illustrates the wide scope of the Iron and Steel Divisions activities. There is one group of papers on ore preparation and blast-furnace problems which include: "Five Years Progress in Southern Blast-Furnace Practice"; "Separation of Hæmatite by Hysteretic Repulsion"; "Porosity, Reducibility and Size Preparation of Iron Ores"; "Relative Desulphurising Powers of Blast Furnace Slags"; "Production and Preparation of Blast-Furnace Flux"; "Carbon in Pig Iron," and a round-table discussion on "Qualities of Pig Iron." Other papers are concerned with physical aspects and with ferrous alloys including: "Temperature Measurements with the Disappearing-filament Optical Pyrometer"; "Some Metallurgical Applications of the C-Si C Thermocouple"; "Origin and Growth of Graphite Nuclei in Liquids and Solid Solutions"; "Surface Magnitisation and Block Structure of Ferrite"; "Initial Stages of the Magnetic and Austenite Transformations in a Carbon Steel"; "X-Ray Study of Iron-Nickel Alloys"; "Preferred Orientations Produced by Cold-Rolling Low-Carbon Sheet Steel"; "Transformation Twinning of Alpha Iron"; "Choosing a Composition for Low-Alloy High-Strength Steel"; "Metallurgy of 'Pure' Iron Welds"; "New Method of Welding Together Ferrous Metals by Application of Heat and Pressure"; and "Action of Solutions of Sodium Silicate and Sodium Hydroxide at 250° C. on Steel under Stress."

It will be seen that the range of work embraced is very considerable, and as the discussion of each paper is included, the volume contains much useful information.

Published by the American Institute of Mining and Metallurgical Engineers, 29, West Thirty Ninth Street, New York, U.S.A. Price $5·00 net.

## The Steel Physical Properties Atlas

This American work gives in graph form particulars of elongation and reduction of area, Brinell hardness numbers, Izod test, yield point and tensile strength of the steels most used in the United States. These particulars are plotted against variations for the percentage of carbon or different methods of heat treatment.

Data on several S.A.E. steels precedes that on cast steels, high-tensile steels, etc. It is much clearer than the necessarily contracted graphs in the 1933 "National Metals Handbook" in the section "Physical property charts for S.A.E. ssteels." It does not supersede by any means the information in the "S.A.E. Handbook" itself, for there is nothing to correspond to the "Effect of mass charts" in that work. The book is a quarto of 88 pages.

By Charles Newman Dawe, and published by the American Society for Metals, 7016, Euclid Avenue, Cleveland, Ohio. Price $2.50 cents.

## Journal of the Institute of Metals

### Volume LVIII (Proceedings) No. 1, 1935

"METALLIC WEAR" formed the subject of a general discussion by members of a number of interested institutions at the last annual meeting of the Institute of Metals. The opening paper by Dr. H. W. Brownsdon is given in this, the latest, volume of the Institute's Proceedings, together with a record of a discussion in which no fewer than 21 experts expressed their views on a subject of the greatest importance to the engineering world.

Following the Presidential Address of Mr. W. R. Barclay, O.B.E., in which he deals with organised development in the non-ferrous metal industries, are 14 papers and related discussions on such subjects as "Effect of Molten Solder on Some Stressed Materials," "Test for Zinc Coating on Wire," "A Deep Drawing Test for Aluminium," "Magnesium Copper Alloys," "The Physical Properties of Nickel-Silver Alloys" and "Experiments on the Electrical Resistance of Copper Wires."

The volume concludes with an account of Mr. C. C. Paterson's May lecture on, "The Escape of Electricity from Metals: Its Practical Consequences." The author traces the effect which the liberation of the electron from metals has had on the trend of electrical engineering during the past twenty years.

Edited by G. SHAW SCOTT, M.Sc., F.C.I.S., The Institute of Metals, 36, Victoria Street, Westminster, London. S.W. 1. £1 11s. 6d.

# Aluminium and Aluminium-Alloy Sheet

By WILLIAM ASHCROFT

*Produced in the form of sheet, plate, coiled sheet and circles, and in various tempers and heat-treatments, aluminium and its alloys are being increasingly used for drawing, spinning, stamping and other forming operations. In this article the author gives brief information regarding grades and tempers to assist the consumer in his selection.*

THE production and application of aluminium and aluminium-alloy sheet has made remarkable progress in recent years, and many developments in operating methods have resulted; it has led, for instance, to the production of heat-treatable aluminium-alloy sheet on a large scale, and special rolling technique has been evolved for dealing successfully with this class of material. At one time it was thought that the operations and technique involved in the production of aluminium sheet were simple, by comparison with the rolling of steel or brass and bronze; but it is now generally recognised that the successful rolling of aluminium and its alloys calls for a special technique which is as complex as that employed in the rolling of other familiar metals and alloys.

Commercially pure aluminium and a wide range of aluminium alloys are rolled into sheet; in addition, composite sheet is available in which a strong base metal is coated with a surface thickness of aluminium. Commercially pure aluminium is a term applied to various grades of aluminium, but, ordinarily, it refers to a metal containing 99 to 99·5% aluminium. The chief impurities are copper, iron, and silicon; the percentages and kinds of impurities depending largely upon the source and grade of the pig metal used for the production of the rolling ingots. Many consumers are more concerned with the behaviour of the sheet in fabricating operations than with its chemical composition, which is unfortunate, because it should be appreciated that the mechanical properties and behaviour in working aluminium sheet depend in part upon the chemical composition, and, in part, upon the specific details of the manufacturing operations in the rolling mill. So long as consumers ignore composition and properties, and have no technical specifications, demanding only that the material will " work," many will continue to get unsuitable material.

### Compositions

As has already been stated, commercial aluminium sheet ordinarily contains 99% minimum aluminium, but sheet containing 98% minimum aluminium is acceptable under some specifications, under others, however, 99% minimum aluminium is demanded. Ordinary 99+% aluminium sheet may contain up to 0·15% copper, 0·35% silicon, and 0·45% iron. Mincr percentages of manganese, zinc and other impurities may be present. For most purposes aluminium sheet of the ordinary commercial 99+% metal is generally satisfactory, providing the impurities are normal. The 98 to 99% grade meets requirements for many purposes where a hard sheet or some intermediate temper can be used, such as when the material is not to be subjected to severe deformation in working, or is not exposed in service to harmful corrosive influences. For deep drawing and spinning, as well as stamping and other forming operations, the grade containing 99%, or over, is normally necessary. Generally, the resistance to corrosion of this grade is superior to that of the less pure grades. For many purposes a sheet of greater purity is required, in the making of aluminium foil, for instance, collapsible tubes, and for certain types of chemical and clinical apparatus.

The aluminium alloys rolled into sheet may be divided into two classes—those that are not heat-treatable, and those that can be heat-treated to develop superior mechanical properties. A fairly wide range of alloys is rolled into sheet to be used for the many purposes that call for a stronger and stiffer material than aluminium, but where the special properties of a heat-treatable alloy are not required. These are frequently referred to as the common alloys, or alloys which are subject only to strain hardening, and do not respond to heat-treatment. They include aluminium-manganese, aluminium-manganese-magnesium, and aluminium-silicon alloys; commercially pure aluminium may also be classed in this category.

Quite large quantities of aluminium-manganese alloy sheet are used in which the manganese content varies somewhat between 1·0 and 1·50%. For purposes which involve the capacity to resist the corrosive effects of sea-water, aluminium-silicon alloy sheet is being increasingly employed. There are quite a number of alloys in this range which contain from 4 to 13% silicon. Small quantities of aluminium-nickel alloy containing 1·0% nickel have been rolled, while other aluminium alloys, in which the alloying element is chromium, copper, magnesium, manganese-silicon, or manganese-magnesium, are rolled into sheet. Some of these alloys are susceptible to enhancement of mechanical properties by quenching, followed by heat-treatment, but they are usually available in the same tempers as aluminium sheet.

There are several alloys which attain their maximum mechanical properties after suitable heat-treatment, probably the most important are those of the Duralumin type, containing copper, magnesium and manganese. Considerable experimental work has been carried out with the object either of improving upon this type of alloy, or in order to provide other strong aluminium alloys, with the result that alloys have been developed which, in addition to the recognised components of Duralumin, include other elements, such as silicon, in varying amounts, or certain elements, such as magnesium, may be increased in percentage together with an appreciable percentage of silicon. Alloys such as aluminium-silicon-magnesium and, with the relative percentages of silicon and magnesium reversed, aluminium-magnesium-silicon, are used to a considerable extent in the form of sheet.

The aluminium-copper alloy is a typical example of a heat-treatable alloy. The copper contents may range from 3·0 to 5·0%: manganese and silicon are usually present in percentages varying between 0·50 and 1·10. In contrast with alloys of the magnesium-silicon and Duralumin types, the aluminium-copper type does not age-harden spontaneously at ordinary temperature after quenching. In order to develop the desired mechanical properties, it is necessary to heat for a considerable period at some moderately elevated temperature after quenching.

The aluminium-magnesium-silicon type of alloy is a self-hardening alloy, but increased strength can be obtained by artificial ageing. As a rule the tensile strength obtainable with this type by heat-treatment is not so high as with the copper-aluminium or Duralumin types. They are rolled more easily, however, and with less waste than either of the other two types of alloys. Most of the other heat-treatable alloys in use as sheet have been derived by some variation in the original composition of Duralumin, a

composition which is based primarily upon 3·5 to 4·5% copper, 0·4 to 1·0% manganese, 0·3 to 0·75% magnesium, and the remainder aluminium with normal impurities, of which silicon is essential. Generally, the best combination of mechanical properties in Duralumin is obtained by quenching, followed by air-ageing, but enhanced properties may be obtained by subjecting it to artificial ageing.

One of the more-important recent additions to the range of high-strength heat-treatable aluminium alloys is that developed and known as "Hiduminium RR 56." This is a more complex alloy, as will be seen from its chemical composition, which comprises 1·5 to 2·5% copper, 0·5 to 1·5% nickel, 0·4 to 1·0% magnesium, 0·8 to 1·3% iron, up to 0·12% titanium, up to 1·0% silicon, and the remainder aluminium. This alloy is available as sheet in the softened, quenched or quenched-and-aged condition, and the D.T.D. specification requires a tensile strength not less than the following figures :—

| | |
|---|---|
| 0·1% proof stress .. .. .. .. | 21 tons per sq. in. |
| Ultimate tensile strength .. .. | 27 ,, ,, |
| Elongation .. .. .. .. .. .. | 10% |

These test requirements show the remarkable progress made in recent years in the development of high-duty aluminium alloys, and may be compared with 5 tons per sq. in. tensile strength and 30% elongation for soft-annealed aluminium sheet, and 7 to 8 tons per sq. in. tensile strength and 4 to 1% for full, hard aluminium sheet.

Composite aluminium sheet has been mentioned in which an aluminium alloy of the Duralumin type is provided with a coating of high-purity aluminium. In this way a material is obtained which combines light weight and high strength with exceptional corrosion resistance, as in the case of "Alclad." The tensile strength and yield strength of this composite sheet are slightly lower than those of the base metal sheet of similar gauge, because of the aluminium coating ; but a minimum ultimate stress of 27 tons per sq. in. may be obtained with a minimum elongation of 8%. More recently, aluminium-coated steel sheets have been applied to industry.

### Kinds of Sheet

Aluminium and aluminium-alloy sheet are produced in various grades, sizes, gauges, tempers and surface finishes to meet the diverse requirements of consumers in the stamping, fabricating and speciality manufacturing trades. Sheet being the term generally applied to aluminium and its alloys which are rolled into flats or coils, and exceed about 8 in. in width. Narrow stock is generally referred to as strip. Flat sheet may be obtained in two kinds of surface finishes—a bright finish or a grey finish. The latter usually applies to sheet of rather heavier gauge. For flat sheet the surface is planished during the time of rolling, highly polished rolls being used. Generally a more highly polished surface is imparted to aluminium than to the alloys by rolling. An extra-polished finish may be obtained by increasing the number of finishing passes when rolling. In addition to a bright surface finish, both aluminium and aluminium-alloy sheet may be obtained in a number of special surface finishes ; for example, satin finish, or scratch brush, and matte or dip finish.

What is probably more important, particularly from a working point of view, is the range of tempers in which sheet is supplied. It is obviously desirable that consumers should be familiar with the grade and temper of the aluminium or alloy sheet suitable for the particular application, and with the work to be done in the making of the finished product. Sheet is available in a wide range of tempers or heat-treatments. The tempers of the common alloys, for instance, depend upon the amount of cold-working or strain-hardening given the metal during fabrication, and range from the annealed or soft condition to the full, hard condition. There are several intermediate tempers between these two extremes which are usually designated as quarter-hard, half-hard and three-quarters hard. It should be remembered that the strength of these alloys increases with increased cold work but the elongation and workability are decreased. This range of tempers gives a corresponding range of mechanical properties which meets general requirements.

The heat-treatable aluminium alloys are generally available in the annealed condition, quenched or solution, or in the fully heat-treated condition. The full heat-treatment comprises both solution and precipitation heat-treatments. The solution heat-treatment consists in raising the metal to a high temperature and then quenching, generally in cold water. In the quenched condition the alloys have reasonable ductility and can be readily worked. Certain alloys, those of the Duralumin type, for instance, if left in this condition at room temperature, will age-harden or undergo the precipitation heat-treatment spontaneously, attaining their maximum properties after about five days. Other alloys, on the other hand, have a stable quenched condition in which reasonable forming operations can be carried out at any time. Subsequent heating at an elevated temperature—120° to 160° C.—is required to give these alloys their maximum mechanical properties.

### Applications

Aluminium and aluminium-alloy sheet in its various forms is applied over such a wide field that it is only possible here to indicate a few uses. Among the many varied uses of commercially pure aluminium sheet are included automobile body panelling, hollow-ware, storage tanks, and tank wagons, chemical equipment, and general sheet-metal work, including that for aircraft and marine use. It combines light weight with excellent resistance to corrosion and the ability to withstand severe forming operations and is readily welded by a number of processes.

The common aluminium alloys in the form of sheet are also readily worked. The aluminium-manganese alloy has greater hardness than aluminium, and greater strength with excellent corrosion resistance, but with lower ductility. It is used for panelling for both private and commercial vehicles, for railcars and railway coaches, and is used in tank wagons, for wheel discs, hollow-ware, and for various architectural purposes. With the addition of a small percentage of magnesium to the latter alloy, higher strength is obtained with equally good corrosion resistance. This alloy is used for side panels, roofs and floors for commercial vehicles, railway coaches, containers, etc., which have to withstand severe service. Forming operations are limited to the softer tempers. In the harder tempers this alloy approaches the heat-treated alloys in tensile strength but has lower ductility. The aluminium-silicon alloys are also used in certain cases for panelling, but their principal application, particularly the high-silicon alloy sheet, is for work where the light weight and excellent corrosion resistance to marine atmospheres are important.

The Duralumin alloy, and those of this type which are designed to conform to similar standard specifications, may be regarded as the standard heat-treated aluminium alloys for structural and aircraft work. In the fully heat-treated condition these combine the strength of mild steel with one-third the weight and have good ductility, permitting reasonable forming. When a considerable amount of forming is necessary the sheet should either have the annealed temper, in which case the product would be heat-treated after forming, or it should be heat-treated, quenched, and the forming done immediately after quenching. Apart from the aircraft industry these alloys are widely used in the transport field, especially where high strength coupled with a reduction in weight are required.

The prices charged for the different kinds and grades of aluminium and aluminium-alloy sheet necessarily vary, depending upon the grade, quantity and size. Considerable saving can frequently be effected if consumers communicate with producers regarding the uses to which the sheet is to be put : in this way the producer, through his technical department, may not only suggest a less-expensive grade, but reduce forming difficulties which might otherwise arise.

# Progress in Iron and Steel Production—Part II

## The New Iron and Steel Plant of Messrs. Guest, Keen, Baldwins Iron and Steel Co., Ltd., at East Moors, Cardiff.

*Development in the economical production of iron and steel has made rapid strides in recent years, particularly in this country where many reorganisation and reconstruction schemes have been executed, and which has been responsible for the substantial rise in production figures. The most recent of the reconstruction schemes to be completed is that at the East Moors Works at Cardiff, which can be claimed to have the most modern plant and layout for the production of pig iron, billets, sheet bars and small sections of various kinds. A description of this plant was commenced in the last issue and is concluded in this article.*

UNDER the above title reference was made in the last issue of this journal to the scheme of re-organisation resulting from the amalgamation of Guest, Keen and Nettlefolds, Ltd., and Baldwins, Ltd., to form the British (Guest, Keen, Baldwins) Iron and Steel Co., Ltd. Part of the reorganisation has involved the erection of a complete iron and steel plant at Cardiff and the coal-handling and washery plant, coke-ovens and by-product plant, blast-furnace plant and steel-melting plant were discussed. In this article it is proposed to describe the soaking-pit plant, the rolling mills, gas distribution, steam-production plant, water-supply services and electric power.

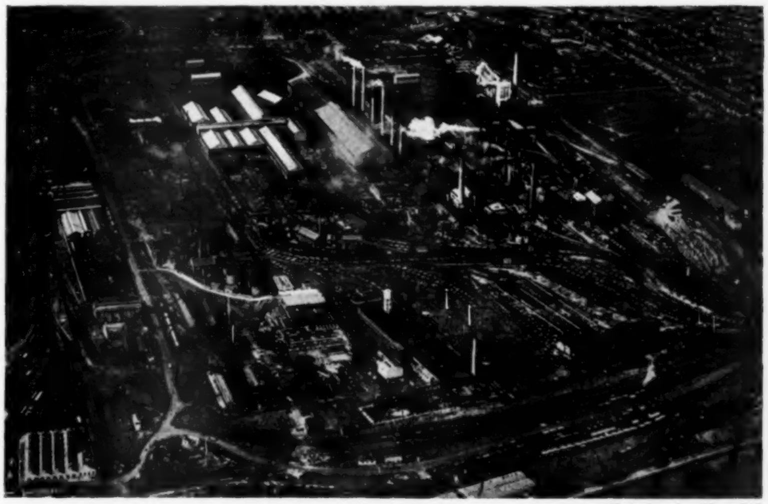


*Photo by Aerofilms Ltd.*

*General view of new works as seen from the air.*

### SOAKING PIT PLANT

The ingot-heating plant consists of five high-efficiency twin-pit soaking-pit furnaces. Each pit accommodates ten 3–4-ton ingots. The total ingot holding capacity for the five twin-pit soakers, is therefore, 100 ingots.

The pits are built on the Isley system, fired with 100% blast-furnace gas. The gas is introduced cold, only the air being heated in regenerators. Through the special application of this system any temperature required for heating the ingots and for running the slag off liquid from the basic bottom is obtained. Each hole is independently controlled, both as to quantity of gas and air and forced draught, each pit having its separate pair of Isley exhaust tubes terminating approximately 35 ft. above ground level. The entrance of air into the pit from outside is thus definitely prevented. The scale formed is kept at a minimum ; the ingots are absolutely evenly heated while as high a rating of heating is obtained as is consistent with the laws of heat transfer. No reversing valves, in the ordinary sense, are used ; only the necessary gate and butterfly valves for reversing the furnaces are installed, and neither of these is exposed to hot gases. Only the heating chambers of the soaking-pit furnaces are placed in the main soaking-pit building. All the control and operating gear is housed in a lean-to adjacent to the main building and operated from one platform running the whole length of the furnaces. The covers are of the rolling type, with one single cover for each pit, suspended from a travelling carriage electrically operated through a rack and pinion gear. The tracks for the covers are entirely independent of the brickwork. The covers are all operated from a central station placed at the middle of the above platform. A slagging platform is arranged between the twin-pit furnaces and the slag is tapped out through two spouts in the outside wall of each pit into slag pots which are handled by overhead crane. For handling the ingots two overhead travelling charging and drawing cranes are provided. The stripped ingots are delivered on railway tracks running alongside the soaking-pit furnaces, and the heated ingots are transferred to the mill by an electric-ingot bogey, distantly controlled, also running the full length of the furnaces. A group of non-fired holding pits is arranged at one end of the building, consisting of 35 separate pits, each to take four ingots, giving a total holding capacity of 140 ingots. The hot-stripped ingots are stored in these holding pits to prevent undue loss of heat until required in the soaking-pit furnaces. The covers for the holding pits are handled by the ingot-charging cranes.

### ROLLING MILLS

The rolling mills consist of a 40-in. sack-blooming mill, a Morgan continuous sheet-bar and billet mill, and a 21-in. three-stand three-high light-section mill, with complete auxiliary plant and equipment, all electrically driven.

The blooming mill has rolls 40 in. diameter by 8 ft. long, with 43½-in. diameter pinions with a 5-ft. 11-in. face, capable of rolling 3-ton ingots down to 5-in. blooms at the rate of 90–100 tons per hour. The mill is driven by an 18,800 peak horsepower reversing electric motor, which is coupled to the pinion housing through a Bibby flexible coupling. The motor has a cut-out torque of 230 metre-tons at 60 r.p.m. and can reverse the mill from 56 r.p.m. in one direction to 56 r.p.m. in the other direction in 2 secs. The mill motor is driven by an Ilgner set with a 5,000 b.h.p. 3,300-volt A.C. motor, which is situated in the main works substation immediately adjacent to the mill motor house.

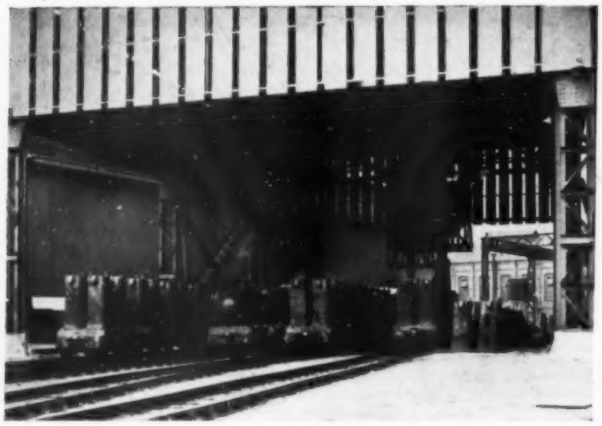


*Photo by Britton and Cox, Ltd., Cardiff.*
*Part of the stripping bay.*

The roll screw-down gear is driven through two 75/150 h.p motors, taking current from a Ward Leonard set installed in the works substation. The mill is fitted with electrically-driven mechanical-manipulator guides on both sides, which are fitted with electrically-operated turning-over steel fingers of special design on the two front guides. The manipulator is of the Friemel type, which enables small blooms to be turned over with ease. Each pair of manipulator guides is driven by a 75-h.p. electric motor, and the manipulator fingers on each guide in front of the mill by one 30-h.p. motor on each guide, driving through worm-gear boxes and connecting rods. The mill scale is collected in cars running on rails in tunnels in the mill foundations, the cars being lifted up and emptied into trucks by the overhead crane. In front and behind the mill rolls a patent breast roll is fitted. The mill-working tables are fitted with forged-steel rollers, all other rollers on the runout racks are in cast iron. All rollers run in white metal oil-pressure ring-lubricated bearings, the line shafts and bevel gears being totally enclosed in oil-tight lubricating troughs. The pinions and pinion bearings are lubricated by oil supplied under pressure by separate oil pumps located in the mill motor house. The mill roll, neck chocks, screw-down gear and manipulators are all lubricated by multified grease pumps, those on the mill being separately driven, while the pumps on the manipulators are driven from the manipulator driving gear.

Ingots are delivered to the mill from the soaking pits by means of an electrically-driven ingot carriage of the self-tipping type. Current for this car is supplied from an underground trench, carrying the necessary collector wires. The mill, its accessories and roller tracks, are controlled from a pulpit erected over the front working table. When rolled the blooms pass to electrically-driven bloom shear of the vertical upcutting type, capable of cutting blooms up to 12 in. × 12 in. section. This shear is driven by a 350 h.p. motor and is provided with a two-speed drive. The control gear is arranged to give continuous or individual cutting (the motor stopping after each individual cut), and a motor-driven measuring stop gear to measure up to 20 ft., with a motor-driven lifting gear, and one motor-driven falling roller on the outgoing side to discharge crop ends into the crop pit.

A deep crop pit is situated adjacent to the shear and it contains at the base a revolving table which carries three large crop-end buckets. As each bucket is filled the table is rotated through 120° and the full bucket removed by the mill overhead crane, and is emptied into specially designed crop-end wagons standing on a track beside the pit, and returned at once to the crop-pit turntable.

If required for the Morgan continuous mill, the cropped bloom passes in one piece, weighing approximately 3 tons without reheating direct to that mill. The cut blooms or billets for outside orders or for the 21-in. section mill are pushed off the roller rack by a strong electrically-driven pusher on to a pawl type transfer bank, from which they fall into an open trough at the end and are received by an overhead crane situated in the bay adjacent to the continuous mill building.

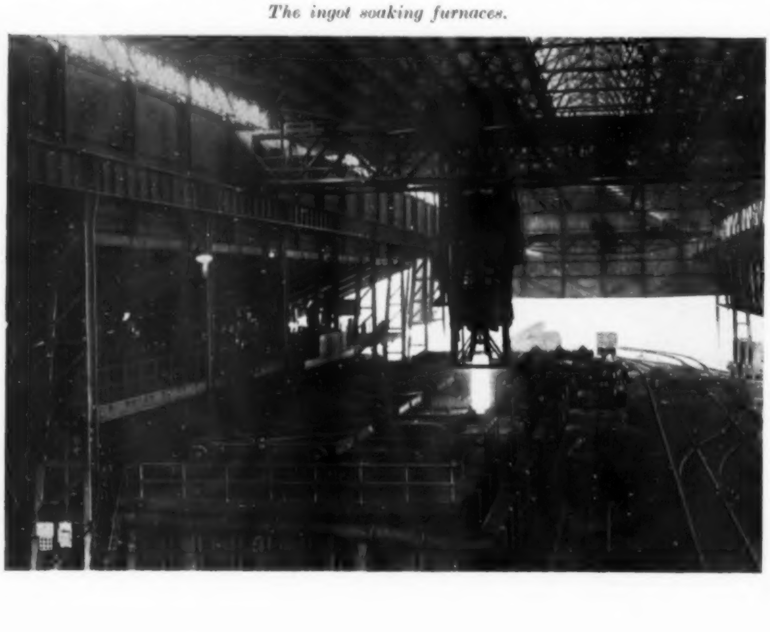
The Morgan continuous sheet-bar and billet mill consists of six horizontal stands of rolls with two vertical edging stands, which are situated in front of horizontal stands 1 and 3, respectively.

The mill is capable of rolling billets down to 2 in. × 2 in. sections and sheet bars down to ¼ in. thickness and up to 16 in. maximum width. The main mill motor has a full load output of 4,000 h.p., and is of the slow speed synchronous type direct coupled to the mill gear box, and housed in a separate motor and switch house in the mill bay. The edging mills are each driven by 125-h.p. motors running at 400/800 r.p.m. Blooms are cut or cropped when required before entering the mill in a shear of the pendulum type designed to cut the bloom when in motion.

The billets and sheet bars when rolled are cut to length by a steam-driven flying shear, controlled electrically from the measuring device. The range of cutting is from 15 ft. to 30 ft. The cut material passes on from the shear to a double-cooling bank, each section being 30 ft. wide by 84 ft. long. These banks deal with the billets only which are delivered to pockets and are removed for despatch by overhead cranes. The sheet bars are delivered to a pair of pinch rolls and a bar-piling frame, which is placed on the cooling bank when sheet bars are being rolled. The bars are lifted from this frame by an overhead claw crane. The roll stands are fitted with Morgoil bearings, the oil for which is supplied from a central oil-pumping station, where oil is filtered for re-use. This same system also supplies the oil to the reduction gears and pinion housings.

The 21-in. light-section mill is of the three-stand, three-high type, designed and constructed by Lambertons, of Coatbridge, with motor-driven tilting tables in front of and behind each stand. The two roughing stands are coupled together and driven from a pinion housing with pinions 21 in. diameter by 26 in. face, which, in turn, is driven by an electric motor of 1,500 b.h.p. through a single reduction gear having flywheels on the high-speed shaft, and capable of dealing

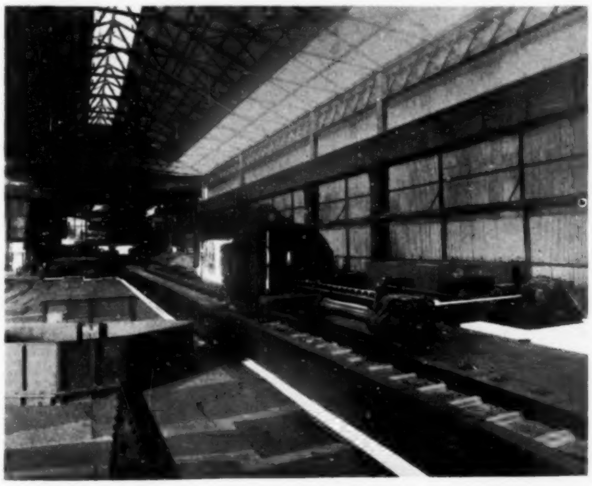
*The ingot soaking furnaces.*



with peak loads of 11,800 h.p. The control gear is arranged to give any mill-rolling speed between 130 r.p.m. and 60 r.p.m. The flywheels have a total stored energy at maximum speed of 35,000 h.p. secs.

The finishing stand is driven from its own pinion housing by a variable speed-motor of 1,200 h.p. driving through a single reduction gear without any flywheels. The maximum mill speed is 160 r.p.m. The finishing mill motor is reversible to enable finished bars to be delivered from either side of the mill. The chocks on all mill rolls are fitted with water-lubricated fabric-type bearings. The tables on both sides of the first roughing stand are fitted with manipulators. The bars are transferred from stand to stand by skids at the rear of the mill. All rollers on the tilting and fixed tables are gear driven, of the unit type, mounted on structural steel-roller frames.

The blooms for this mill are heated in a continuous furnace fired with blast-furnace gas. Provision is made for the addition of coke-oven gas if required. The furnace is of the cross-fired automatic reversing type. Air only is regenerated, the gas being preheated in the metal recuperators. Except in the hearth, which is of magnesite and air-cooled underneath,



*Showing complete roller path and shears behind the Sack mill.*

the blooms are pushed on water-cooled skids, the firing being from underneath, as well as on top. The draught is maintained by fan. The heating capacity is 25 tons of 8 in. square by 16 ft. cold blooms per hour. The blooms are pushed by a direct type hydraulic pusher. An intensifier is fitted for use with very heavy blooms. The blooms are pushed one at a time off the magnesite hearth on to water-cooled skids down which they fall on to the roller run to the mill. Both the pusher and discharge door are controlled from the discharge end of the furnace.

The sections rolled in this mill are delivered to two motor-driven saws having pressure-oil-feed gear. These saws are adjustable in position to secure the maximum throughput when cutting multiple lengths, which can be dealt with in all lengths up to 33 ft. Two cooling banks are provided, each 60 ft. wide by 72 ft. long, the delivery rack to the banks having individually-driven rollers. The bank nearest the mill has 8-skid ropes and the second bank 7-skid ropes.

Finished material after cooling is pushed into delivery pockets and removed by overhead crane for despatch or transfer to the finishing departments.

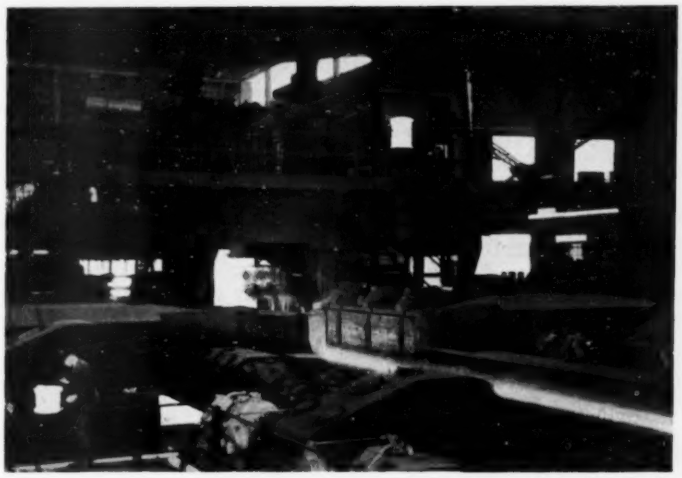


*Photo by Britton and Cox, Ltd., Cardiff.*

*The Sack blooming mill in operation.*

## GAS DISTRIBUTION

### Blast-Furnace Gas

Clean gas from the Lodge-Cottrell plant cleaning units is passed into the collecting main at 8 in. to 11 in. W.G. pressure. A network of distribution mains extends through the works, with a Klonne waterless gas holder of 3,000,000 cub. ft. capacity acting as a storage and pressure balancing medium. The piston sealing ring consists of two bands of special composite packing with a grease cavity betsween, and the piston weighs 275 tons and throws a pressure of 8 in. W.G. when in contact with gas. The speed of travel is limited to 18 in. per minute. The total weight of the holder and piston is 1,100 tons. The branch to the holder is 36 in. diameter, and a valve water seal and a valve which may be electrically operated from the control room, ensures the rapid isolation of the holder in case of emergency. The branch gas mains are provided with valve water seals, at points before the various consuming units, so that each consumer may be rapidly isolated from the supply main, if necessary. The total volume of gas cleaned and consumed per week at the present time is 1,200,000,000 cub. ft. The following figures indicate the percentages of the total gas produced which are consumed by the main operating units:—

| | | % |
|---|---|---|
| 1. | Blast-Furnace Stoves | 19·6 |
| 2. | Boilers | 24·7 |
| 3. | Coke-Ovens Plant | 15·5 |
| 4. | Melting Shop | 15·2 |
| 5. | Soaking Pits | 8·5 |
| 6. | Billet Reheating Furnace | 2·8 |

*Back view of blooming mill showing part of roller path.*

*Photo by Britton and Cox, Ltd., Cardiff.*

*Photo by Britton and Cox, Ltd., Cardiff.*

*The Morgan Mill.*

### Coke-Oven Gas

Scrubbed gas is passed on from the coke-ovens plant to a second distributing system which serves the melting shop and may serve the soaking-pits and billet reheating furnace. A 1,000,000 cub. ft. capacity Klonne waterless gas-holder serves as storage and pressure balancing medium. The piston weighs 150 tons and the total weight of the holder is 550 tons. The appliances for isolating the holder are duplicates of those previously described, the electrically-operated valve being operated from the coke-ovens exhauster house. The distribution main, 27 in. diameter, runs parallel to that for blast-furnace gas, and a volume of 62,000,000–68,000,000 cub. ft. of gas is distributed per week. The melting furnaces consume 80–85% of the total gas produced, whilst a variable volume is consumed by the coke-oven plant.

### Mixing of Blast-Furnace and Coke-Ovens Gas

The separate mains of the two gases are supported together on trestle supports and branches lead off to the consuming units. Each melting furnace has its own gas-mixing arrangement. The volume of each gas entering the mixing cylinder is regulated by hand-operated valves. Orifice plates are fitted into each branch pipe, and recording meters on the melting-shop platform serve to show the furnace operators that the mixture is correct. Askania and Arca pressure regulators are inserted respectively in the 5-ft. diameter boiler main and the 3-ft. 9-in. main to the soaking pits.

*Priest's reheating furnace for serving the Lamberton mill.*

*Photo by Britton and Cox, Ltd, Cardiff.*

### Communication and Alarm System

1.—The control house attendant is in communication with all consuming units by automatic telephone. The telephone system is part of the main general system for works, but arrangements have been made so that telephones on the gas distribution system have priority over all others. Loud ringing relay bells are worked in conjunction with the telephone service in order to draw the immediate attention to the furnace operators.

2.—By means of Midworth distance repeaters and electrical transmitters, actuated by the movements of a mechanical gas stock indicator on each gas holder, the instantaneous stock of gas available is communicated to the control house attendant, the coke-ovens exhauster man and the responsible furnace man at each of the consuming units. To each gas stock indicator is attached an alarm relay which, when fixed at any stock figure, causes a klaxon to sound for 20 secs., and a red light to show. This is a signal of gas shortage, and the consuming unit attendant, in accordance with the emergency instructions issued or from telephonic communication with the control-house attendant, reduces the consumption of gas to a minimum or ceases to consume gas entirely.

## STEAM PRODUCTION PLANT

The steam-producing plant is divided into two sections —the main boiler plant and the waste-heat boiler plant —which deliver steam at 160 lb. per sq. in. into common mains.

### Main Boiler Plant

This plant consists of six Babcock and Wilcox water-tube boilers with combustion chambers fitted with Harrison gas burners. Each boiler is rated at 12,000 lb. of steam per hour, and can burn blast-furnace gas, coal or coke breeze. Arrangements have been made to fit these boilers with oil burners. Four spearing water-tube boilers, built by Edwin Danks and Co., and fitted with Harrison gas burners for blast-furnace gas. Each boiler is rated at 12,000 lb.of steam per hour, and may be fired with blast-furnace gas, coal or coke breeze. Two Lancashire boilers also built by Edwin Danks, each 30 ft. by 9 ft. and rated at 8,000 lb. of steam per hour, fired with gas, coal or coke breeze. All the boilers are fitted with superheater tubes. Two Babcock and Wilcox water-tube boilers, each of 12,000 lb. of steam may be fired with blast-furnace gas or powdered fuel. The coal is crushed by beater mechanism, so that 90% passes through 200 mesh sieve. The powdered fuel passes direct from the pulveriser to the hearth of the boiler and ratings up to 15,000 lb. of steam per hour have been obtained. Four John Thompson "Beta" type water-tube boilers were completed this year, each having a heating surface of 7,000 sq. ft. Three of the boilers are fitted with forced-draught chain-grate stokers suitable for burning coal and/or coke breeze, and "Gako" forced-draught gas burners for burning blast-furnace gas. The fourth boiler is fitted with hand-fired grate as well as gas burners. The normal evaporation per boiler is 35,000 lb. per hour, with overload 42,000 lb. per hour. The steam is superheated to 100° F. Three boilers are served with a coal-handling plant, consisting of a 24-ton receiving hopper, a chain and bucket elevator overhead coal band-conveyer and separate coal and breeze bunkers. An ash handling equipment consisting of ash wagons, turntables, a skip hoist and an ash bunker deals efficiently with the ash. The Green economiser plant for the above boilers consists of 5 units and a total of 1,440 water tubes. The feed water is preheated to an average temperature of 210° F. There are three Weir turbo-driven feed pumps, two each of 200,000 lb. per hour and one of 350,000 lb. per hour.

### Waste-Heat Boiler Plant

Waste gases from the steel furnaces and mixer furnace pass through waste-heat boilers. The 200-ton tilting furnaces each have Spencer Bonecourt twin-drum boilers which evaporate from 15,000–20,000 lb. of water. The mixer and the two 80-ton fixed furnaces each have an Adamson single-drum boiler which evaporates 8,000–12,000 lb. of steam per hour. The steam from all boilers, is superheated to 100° F. There are two feed-water pumps, each 120,000 lb. per hour capacity. One by Paul, Royd and Brook, electrically driven, the other being a vertical steam reciprocating pump by Pearn and Co.

A water-softening plant of the Kennicott type deals with incoming commercial town's make-up water.

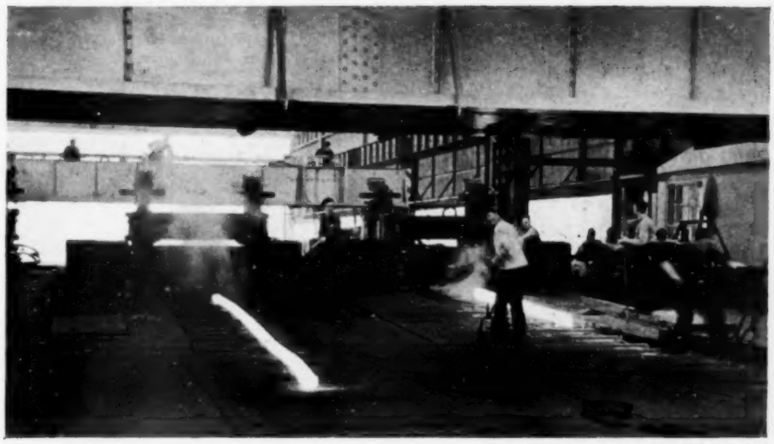


*Photo by Britton and Cox, Ltd., Cardiff.*

*The Lamberton Section mill in operation.*

### Consumption of Steam

The total hourly consumption of steam is 180,000–190,000 lb., of which approximately 100,000 lb. per hour is consumed by the blast-furnace turbo blowers and the blast-furnace water cooling pumps. This water is condensed and returned to boiler feed. The remainder of the steam is utilised by the coke-ovens exhauster engine, hydraulic engines, electric D.C. turbo generator and general works uses.

## WATER SUPPLY SERVICES

The bulk of the water required for cooling purposes is drawn from the north end of Cardiff East Dock, and after use returned to the same dock at a point about half-way along its length—the area used being sufficient to provide adequate cooling throughout the year. The water from the dock is taken through a 5-ft. diameter main of reinforced concrete into a divided sump under the floor of the pump house from which the water is distributed throughout the works. This pump house, situated at the north end of the plant, contains a number of pumps which are all of the vertical spindle bore-hole type with submerged pumps. There are three pumps for supplying the water for the blast furnaces; three pumps for the melting shop and two pumps for the mills and coke ovens. Near the pump house is situated a tower containing a high-level tank at 140 ft. above ground level and a low-level tank at 70 ft. above ground level. The water supplied from the north pump house to the blast-furnace department is there dealt with by a number of separate pumps and water tanks. In order to safeguard against any possibility of breakdown, ring water supply mains are provided for the blast furnaces and the melting shop.

The waste water from the mixer and open hearth furnace bodies is taken off at as high a level as possible below the charging platform so as to get sufficient head for this water to be delivered without pumping to the dock. The water from the valves in the open-hearth plant, from the mills and the coke ovens is dealt with by means of vertical low-lift pumps which discharge into the return main to the dock. Waste water from the blast furnaces is delivered direct into the return water main. All incoming and out-going water, as well as the water at the different points of use, is recorded by a number of meters. In addition there exist some well pumps for supplying specially cool water to the coke ovens and also to act as an emergency supply. As an additional safeguard, a certain amount of water is available from the Cardiff Corporation commercial water-mains. Generally this is used for boiler feed.

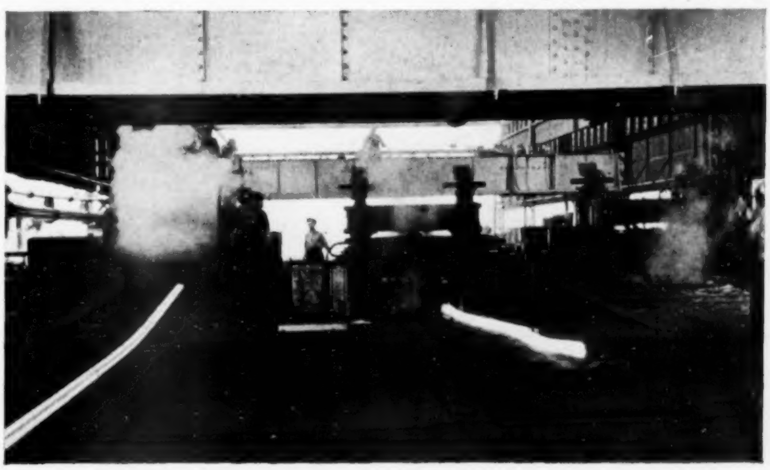
## ELECTRIC POWER

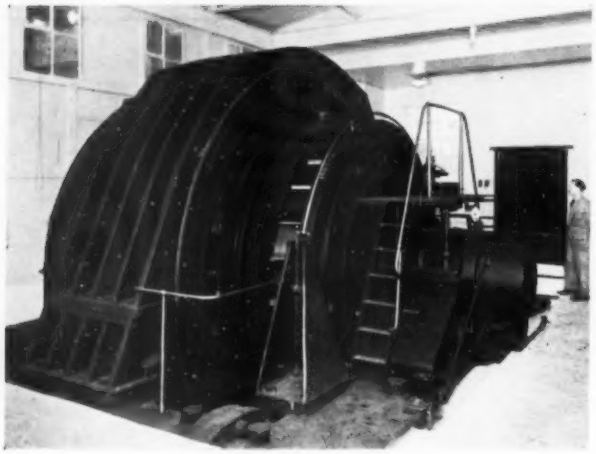
In a self-contained iron and steel works such as this where, with few exceptions, the whole of the machinery is electrically driven, the supply of power is obviously a works service of the first importance. Considerations of reliability, capital cost and space, as well as the short time in which the supply had to be made available, all weighed heavily against the installation of generating plant, so that when, as a result of connection with the Central Electricity Board's "grid" system, the Corporation of Cardiff were able to offer terms comparable with the estimated cost of independent generation, the decision was made to purchase power and to utilise the whole of the surplus blast-furnace and coke-oven gas for other purposes. A full alternative duplicate supply is provided from the Roath Power Station of the Cardiff Corporation, by means of two 33,000-volt feeder cables. These cables terminate at the central substation of the works, outside which there are two 15,000 k.v.a. transformers belonging to Cardiff Corporation which step down the voltage of supply from 33,000 volts to 11,000 volts.

The distribution problem has been regarded comprehensively, with regard to initial and future requirements, so that the distribution system is in a position readily to meet increased demands. Unsightly and, when arranging for works extensions, inconvenient overhead lines are absent. All main cables are carried underground with advantage from every standpoint. Inter-connections of main distribution centres at 11,000 and 3,300 volts A.C. or 480 volts D.C. has been provided to ensure that each important service has two alternative supplies available.

*The Lamberton Section mill in operation.*

*Photo by Britton and Cox, Ltd., Cardiff.*





*20,000 h.p. Mill motor.*

Main distribution is at 11,000 and 3,300 volts A.C., the latter through a ring main feeding four substations, where it is transformed to 400 volts. Current is used for motors at 3,300 and 400 volts A.C. and 480 volts D.C., while lighting is mainly at 115 volts A.C.

Amongst the large individual 3,300-volt motors are these :

(1) 5,000 b.h.p. 600 r.p.m. motor driving the Ilgner set for the blooming mill.

(2) 4,000 b.h.p. 100 r.p.m. synchronous motor driving the Morgan continuous mill. This equipment is thought to be the most powerful for this type of rolling mill service in Great Britain.

(3) 410 b.h.p. 2,900 r.p.m. squirrel-cage motor driving a hydraulic pump, a striking contrast to the slow-speed machine just mentioned.

Power factor is maintained at between 0·95 and unity for the mill drives.

Direct current at 480 volts is used for cranes and for mill auxiliaries and similar drives in which variable speed or repeated starting is required in addition to the main drives of the blooming mill and section mill. Direct current is obtained from five 2,000 k.w. rotary converters and from previously existing steam-driven generators of about 2,000 k.w. total output. The latter can be used to provide a supply for essential services should the main supply fail. The following are the principal D.C. motors :

*General view of electric power house.*

*Photo by Britton and Cox, Ltd., Cardiff.*

(1) The 20,000 maximum h.p. reversing motor driving the blooming mill. This is supplied from its own Ilgner set at 1,470 volts, and is one of the most powerful single-armature motors in present use.

(2) The 1,500 h.p., and 1,200 h.p. reversing motors driving the three-high section mill.

(3) The 350-h.p. motor driving the bloom shears. This is a special equipment designed to meet very exacting conditions. The shears are required to make five separate cuts a minute on 12 in. by 12 in. blooms, or to run continuously when the operation of the shears is automatic, slowing down between each cut to enable the bloom to be traversed. The motor has a high acceleration with a top speed of 960 r.p.m., and is equipped with dynamic and potentiometer braking in addition to a solenoid brake.

(4) Two 150 h.p. motors connected in parallel for operating the blooming mill screw-down. Although a D.C. supply was available, these are supplied on the Ward Leonard system from independent motor generators in order to secure the rapid and accurate control necessary to meet the high speed of operation of the mill.

It will readily be realised that with the main supply of power obtained from a power station buttressed by the national "grid" and with power distribution on the scale already described, the switchgear and cables require effective protection against the very heavy momentary surge currents to which they might be subjected in the event of a short circuit. The Corporation agreed to control the primary supply so as to limit the maximum short-circuit surge on the 11,000-volt system to 350,000 k.v.a. and the 11,000-volt switchgear has been installed of that rupturing capacity. The transformers reducing the voltage from 11,000–3,300 and from 11,000–400 are so designed and grouped as to limit the shock surge to 100,000 on the 3,300-volt system and 25,000 on the 400-volt system, thereby allowing the use of ordinary commercial 3,300-volt and 400-volt switchgear. The 11,000-volt system is provided with completely discriminative automatic protection so that on the occurrence of a fault only the switch or switches necessary to isolate the fault will open. As duplicate supplies are provided throughout, there is little risk of an interruption of supply due to any single fault on the 11,000-volt system. On the lower voltage systems continuity of service is provided for by alternative supplies for every important duty. Should the supply in use fail, current can immediately be restored by closing the switch controlling the alternative supply. On both the alternating and direct current distribution systems the protection of cables and the protection of motors have been kept distinct. Motor controllers and starters are relied upon to protect motors from overload, but the supply cables are protected by either an automatic circuit breaker or by high rupturing capacity fuses, which serve also as a back-up fault protection for the motor and its controller. As the rating of all fuses and circuit breakers is well above any load which the motor can draw from the supply in normal operation, they are called upon to operate only in the event of short-circuit or electrical failure. The whole of the electrical plant was supplied and installed under the supervision of Messrs. McLellan and Partners.

We are indebted to Messrs. Guest, Keen, Baldwins Iron and Steel Co., Ltd., and especially to Mr. J. S. Hollings, Managing Director, for permission to view these works, take photographs and for permission to publish this description of the plant.

# Copper Castings Alloyed with Beryllium and Titanium

*The results of an investigation on the hardness and electrical conductivity of copper castings containing beryllium and titanium are discussed.*

ROCKWELL hardness tests and electrical conductivity measurements on copper castings containing up to 2·7% beryllium and up to 1·2% titanium formed the subject of a recent investigation by G. F. Comstock.[1] These alloy castings were heat-treated in various ways in order to determine the best combination of hardness and conductivity. Larger percentages of the alloying elements were not tried, both on account of the expense involved, and also because of their adverse effect on the electrical conductivity.

The beryllium alloys were prepared by melting copper and adding beryllium either in the form of 12·5% beryllium copper, or from a 2·5% alloy, or from remelted scrap. To prevent serious loss of beryllium, charcoal was used as a cover. Titanium was added to superheated copper under a glass cover in the form of fine metallic particles by means of a small graphite phosphoriser, and the loss of titanium did not exceed 20%. All the titanium melts were deoxidised with 1% of a calcium silicon alloy. The castings of both beryllium and titanium alloys were poured in dry-sand cores, 16 in. long and ⅝ in. wide, gated near one end, and with a riser at the gate.

The hardness tests were made with the standard Rockwell machine using the E* scale (⅛-in. diameter ball and 100 kgm. load) on ¼ in. thick sections cut from the test bars. Ten determinations were made on each specimen, the average being taken after discarding one or two abnormally low or high results. The conductivity tests were made with a Kohlrausch bridge arranged with a standard resistance in a special assembly designed for cast copper rods and gave results accurate to within 0·5%. The test specimens were machined to ½ in. diameter for a length of 14·5 in. Corrections were made for the temperature of the specimen, when tested, and results were reported as conductivity by mass (or per metergram) in per cent. of the standard value for pure copper. The various heat-treatments were carried out in an electric furnace with automatic temperature-control, the furnace being brought up to the temperature before inserting the specimen.

In copper alloys containing either beryllium or titanium, a compound is held in solution at temperatures around 870° C. and precipitates from solution at lower temperatures. This precipitation may be prevented by rapid cooling from the solution temperature, and then, on reheating to a lower temperature, separates into very fine particles and causes hardening and an increase in the electrical conductivity. The effect of these changes in a beryllium alloy and in a titanium alloy are shown in Table I.

TABLE I.

| Alloy Content. % | Heat Treatment. | Rockwell Hardness, E. | Electrical Conductivity, %. |
|---|---|---|---|
| 2·04 Be | None. As cast | 90·0 | 22·0 |
| | Quenched from 800° C. | 74·5 | 18·8 |
| | Tempered 5 hours, at 370° C. | 118·0 | 32·8 |
| 0·87 Ti 0·35 Si | None. As cast | 80·0 | 27·3 |
| | Quenched from 900° C. | 49·0 | 26·9 |
| | Tempered 48 hours at 455–510° C | 87·0 | 46·5 |

The hardness and conductivity obtained in copper alloys containing titanium but no beryllium have been found to depend largely on the silicon content which is present with the titanium. Castings containing 0·5–0·9% titanium and 0·03–0·19% silicon had a Rockwell hardness of about 88 E and 24–36% conductivity after quenching from 900° C. and tempering 24 hours at 455° C. When the silicon content was 0·23–0·40% the Rockwell hardness was about 85 E and the conductivity 42–45% after the same heat treatment. The tensile properties were about the same for each class, namely 9·0–13·5 tons per sq. in. yield point with 15·0–20·0 tons per sq. in. ultimate strength and 7–27% elongation. By tempering at about 565° C. instead of 455° C. the conductivity was raised to 65 or 70% but with Rockwell hardness of only 67–74 E and yield point about 8·0 tons per sq. in. Pure copper castings of 85–90% conductivity had a yield point of 2·7–4·0 tons per sq. in., an ultimate strength of 7·5–9·0 tons per sq. in., an elongation of 40–50%, and a Rockwell hardness about 35 E.

The temper-hardening properties of titanium-copper alloys with additions of 2–6% cobalt, 2–6% nickel, 4–7% zinc, and 0·8% aluminium were also investigated. All of these alloys could be hardened by tempering, but those with silicon and zinc were the only alloys which showed as much temper-hardening as the plain titanium copper alloys.

As a result of experiments carried out on cast beryllium-copper alloys with and without titanium and on titanium-copper alloys without beryllium, it was shown that in alloys with about 1% or less of beryllium, the presence of this element with titanium appears to give a lower conductivity and not greater hardness than would be expected in similar alloys with titanium alone, and in alloys with over 1·1% beryllium the presence of titanium seems to reduce the conductivity slightly without appreciable increase in hardness after heat treatment. As a means therefore of securing the best combination of hardness and conductivity at room temperature after ordinary heat-treatment the use of both elements together in copper does not seem necessary.

Preliminary heat treatment experiments with quenching temperatures varying from 800°–870° C. and tempering temperatures varying from 315°–370° C. for the copper-beryllium alloys and from 315°–510° C. for the copper-beryllium-titanium alloys together with double-quenching temperatures of 840° and 390° and 840° and 425° C. for two of the copper-beryllium-titanium alloys and a double tempering at 510° and 315° for a copper-beryllium alloy containing 0·52% beryllium showed that the maximum hardness of beryllium alloys containing titanium was developed after a longer tempering period than with titanium absent. Since it was also shown that the titanium alloys required a higher tempering temperature than the beryllium alloys, it was concluded that the former alloys would retain their hardness to a greater degree and for a longer time, when heated, than the latter. Experiments were carried out, therefore, to show the softening effect of temperature and time on some of these alloys after they had been heat treated to give maximum hardness.

The results of such experiments showed that beryllium alloys decreased in conductivity, as well as hardness, when they were overheated for considerable periods of time. A plain beryllium alloy was best when tempered at 315° C., but at higher temperatures the hardness of titanium-bearing alloys did not drop so fast as did an alloy containing the same beryllium content without titanium. The conductivities of the alloys containing both beryllium and titanium were inferior to those of alloys with each element separately, but the conductivity of a beryllium alloy without titanium

[1] *Metals and Alloys*, 1936, Vol. 7, pp. 257—260.
*70E = 65 Brinell, 100E = 125 Brinell, 115 = 250 Brinell.

dropped more rapidly on overheating, so that after exposure to 480°–540° C. its superiority in conductivity was negligible. It would appear from these experiments that the beryllium compound goes back into solid solution at such temperatures, while the titanium-silicon compound does not, since the conductivity of alloys containing only the latter compound and no beryllium is improved by heating up to 560° C.

The function of titanium in beryllium-copper seems to be the stabilisation of the hardness at higher temperatures than could be produced, without softening, by plain beryllium-copper. A considerable advantage might, therefore, be obtained in such parts as welding contacts, where conductivity is essential as well as hardness on heating, or in springs that must maintain their original properties above 315° C.

# Production Development in Soviet Metallurgy

## By A Special Correspondent

*Production expectations from Soviet iron and steel plants have been exceeded, largely as a result of improvements in working the plants, to such an extent that new plants scheduled for erection have been found unnecessary.*

THE objective set before the Soviet iron and steel plants is to achieve a daily output of 60,000 tons of steel. If this is achieved it will exceed the daily output of 46,000 tons estimated in the Second Five-Year Plan for 1937, and put the U.S.S.R. first in respect of steel production in Europe. The metallurgical industry inherited from the former regime required colossal reconstruction. During the years of the Civil War the annual production of iron fell to 115,000–117,000 tons, as against 4·2 million tons during the pre-war period. The output of steel was only brought up to pre-war level in 1929. Since that year a radical reconstruction of the Soviet steel industry began to take place.

During the four years 1931–34, 6,600 million roubles were invested in ferrous metallurgy. The new metallurgical base in the East became a reality. In 1934 it produced 31% of all the steel cast in the Soviet Union and 25% of all the rolled steel produced in the country. During this period 11 new steel-smelting plants were put into operation. Including the new units rebuilt on the sites of the old plants, 75 open-hearth furnaces began to function, 63 electric furnaces, 6 blooming mills and 29 rolling mills. The open-hearth departments were fundamentally reconstructed. Of the 231 furnaces existing in 1931 not a single one had a useful volume of 50 sq. metres. In 1935 there were 329 furnaces with an aggregate useful volume of 8,438 sq. metres, of which 33% were furnaces with a useful volume of 40 sq. metres and over. Among these are 22 150-ton furnaces hitherto unknown to Soviet metallurgy. Electro-metallurgy was practically created during the years 1931–34. Early in 1931, the Soviet steel industry possessed 18 electric furnaces, by January 1, 1935, the number had increased 3·3 times.

The number of rolling mills during the same period increased from 236–272. The new rolling mills are among the finest and largest in world metallurgy. For instance, one rail mill at the Kuznetsk plant has a productivity equal to 90% of the entire pre-war rail production. In 1935 there were put into operation 29 open-hearth furnaces, 20 electric furnaces, 17 rolling mills and 5 pipe-rolling mills. The 1936 plan provides for the construction of 13 more open-hearth furnaces, including seven large ones, also 14 rolling mills, one tube-rolling mill, etc.

The year 1935 was the turning point in Soviet steel production. Metallurgists were given the task of increasing steel production to such an extent that it outstripped the continually increasing output of pig iron. That this task was fulfilled may be seen from the following figures :—

| Average Daily Output in | Pig Iron. Tons. | Steel. Tons. | Rolled Steel. Tons. |
|---|---|---|---|
| 1933 | 19,400 | 18,600 | 13,900 |
| 1934 | 28,600 | 26,100 | 19,300 |
| 1935 | 34,200 | 34,100 | 26,000 |
| 1936 (nine months) | 39,200 | 43,100 | 32,800 |

From September, 1935, the output of steel began to outpace that of pig iron, even though the latter kept on increasing. The big upward jump in the figures for the first nine months of 1936 are due to the revolution in operation methods.

Last February and March, conferences of metallurgists were held in the Soviet Union to consider the new situation in the metallurgical industry created by the Stakhanov methods of work and to fix new figures and standards in the light of the new labour productivity. Whereas the average production of steel per sq. metre of useful volume was 3·9 tons in 1935, on the basis of the Stakhanov experiences, the conferences resolved to fix the average output of steel per sq. metre at 7–8 tons. This had the effect of doubling the output capacities of the rolling mills as compared with 1935.

On the basis of these new production figures, new estimates were made of the output capacities of plants. This led to some surprising results. For instance, the project for the Magnitogorsk Metallurgical Plant, which was drawn up in 1930 with the aid of American firms, has now been revised with the following result :—

| | McKee project. | Revised project. |
|---|---|---|
| Number of open-hearth furnaces | 31 | 29 |
| Annual production of steel | 2,700,000 | 4,770,000 |
| Number of rolling mills | 12 | 6 |
| Annual production of rolled steel | 2,100,000 Tons. | 3,710,000 Tons. |

Similar revisions were made in regard to the output capacities of other plants, with the result that on an average the originally estimated capacities of steel and rolled-steel plants were almost doubled. This increase in the capacities of existing plants and plants under construction will make it possible to reduce the number of new metallurgicaal plants scheduled for construction under plan, with a consequent saving. According to Mr. A. Gourevich, head of the Central Administration of the Soviet Metallurgical Industry, the realisation of the new production capacities will make it possible to obtain 23 million tons of steel a year from the units in operation (being 6 million tons more than was estimated as the production for 1937), and with the opening of the steel units now under construction, the output will be brought up to 25 million tons a year, or 70,000 tons per day.

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The overhauling of the Panama Canal lock gates was completed last year. Thirty gate leaves out of a total of 92 were replaced as a result of the heavy wear during over 20 years' constant service. The heavy gates were raised clear of their pintles by jack units, each ram of which was provided with a rocker disc of nickel steel to take the load. It is noteworthy that the pintles are of cast-nickel steel.

# Present Trend in Alloy Constructional Steels

*High-strength constructional steels are being employed to an increasing extent to meet the needs of engineering developments, and the discussion by Mr. J. A. Jones at a recent meeting of the Midland Metallurgical Societies, the salient features of which are given in this article, gives the trend of development of these steels.*

CHROMIUM steels were among the earliest alloy steels to be used in connection with engineering construction. However, it was from the use of nickel steels for the manufacture of armour plate that the utility of the typical alloy-constructional steels spread through many branches of industry. Nickel steels of the type under consideration contained about 3·5% of nickel with carbon 0·30–0·40%, and the type has remained in continuous use since its introduction. All the mechanical properties of 0·40% carbon steel in the oil-hardened and tempered condition are improved as a result of the addition of nickel up to about 6·0%. No advantage is gained by increasing the nickel content beyond this limit, and with manganese contents of the order of 0·80%, no advantage is gained by exceeding 4·5% of nickel. It would appear that even above 3·5%, the extent of the improvement in mechanical properties is hardly compatible with the additional cost of the steel.

After oil-hardening and tempering, the mechanical properties of 0·40% carbon steel are markedly improved as a result of the presence of chromium up to about 2·0%. For many purposes, where it is desired to replace carbon steels by steels of greater strength chromium steels of the following analyses have been suggested :—

Carbon 0·40–0·35%. Chromium 1·5–2·25%.
Carbon 0·35–0·30%. Chromium 2·25–3·0%.

Chromium steels show very marked advantages in respect of ease of machining over nickel steels of similar tensile strength. The steels of higher chromium content are susceptible to temper brittleness if slowly cooled from the tempering temperature. Unfortunately chromium steels are particularly susceptible to the development, during rolling, of surface markings generally referred to as " chrome lines," the removal of which necessitated the introduction of rough turning in the course of manipulation. Nevertheless these steels are appreciably cheaper than 3·0% nickel steels.

The presence of manganese up to about 2·0% has a beneficial effect on the mechanical properties of oil-hardened and tempered 0·40% carbon steel. The following range of analyses has been suggested :—

Carbon .........0·40–0·35%
Manganese ...... 1·8–2·2%

Commercially there appears to be some diffidence in developing constructional steels with manganese content as high as 1·8%, with carbon contents of 0·35–0·40%, the highest limit of manganese appearing to be about 1·7%.

Steels containing 0·30–0·40% carbon and low percentages of tungsten have not received any commercial application as constructional steels, and although results obtained by Swinden on steels with various carbon contents showed the toughening effect of tungsten, its influence is not sufficiently pronounced as to warrant any special recommendation in its favour.

The addition of molybdenum to carbon steels has a marked effect in raising the elastic limit, yield point, maximum stress and notched-bar impact figure, whilst up to about 0·60%, the figure for percentage elongation remains relatively high. The valuable effect of molybdenum is greatly intensified in the presence of other hardening elements, and it is in this field that molybdenum finds its main application.

Vanadium, in the same manner as other alloy elements, exerts a beneficial effect on the properties of heat-treated steels. Plain vanadium steels are only used to a very limited extent for constructional purposes, but chrome-vanadium steels containing about 0·15% vanadium have found a wide field of application for small and medium-size sections.

Development in the properties of the 3·5% nickel steel was sought in the first instance by the addition of chromium. The composition of the original type was obtained simply by the addition of about 0·75% chromium to the 3·5% nickel steel. Unfortunately this type of nickel-chromium steel is normally susceptible to temper brittleness. The results of tests indicate that in nickel-chromium steels of this type in sections 2½ in. square, an increase in the susceptibility to temper-brittleness when air-cooled is evident for phosphorus contents over 0·034%. When the tensile properties cannot be obtained by tempering outside the temper-brittle range, susceptibility to temper-brittleness may be overcome by addition of molybdenum. Even if the nickel content be reduced to 1·6–1·8%, without increasing the chromium content beyond 1·25%, the properties are at least equal to those obtained in 3·0–3·5% nickel steel. Combinations which have found useful applications as constructional steels are as follows :—

Carbon 0·25–0·40%. Nickel 1·0–1·5%. Chromium 0·50–1·0%.

Substitution of part of the nickel in nickel steel by manganese results in a reduction in price with improvement in mechanical properties. The types of steels developed on these lines and in general use for constructional purposes contain :—

Carbon 0·35–0·40%. Manganese 1·0–1·2%. Nickel 1·0%.
Carbon 0·35–0·40%. Manganese 1·25%. Nickel 1·75%.

The former will meet requirements for 48 tons per sq. in. tensile strength and the latter 55 tons per sq. in. tensile strength. The nickel-manganese steels suffer from temper-brittleness in the same manner as nickel-chromium steels, and this may be overcome in the same way by the addition of molybdenum.

As the percentage of molybdenum required in combination with another less expensive alloy element is usually of the order of 0·30%, such steels have found a ready market as substitutes for steels of high-nickel content. The addition of molybdenum to chrome steels results in marked improvement in mechanical properties, whilst the steels are very easily machined even when hardened and tempered to high-tensile strength. Steels containing approximately 0·35% carbon, 1·0% chromium and 0·35% molybdenum are admirable substitutes for 3·0 and 3·5% nickel steels, giving similar mechanical properties at slightly reduced cost, but with very definite advantages in possessing a wider tempering range with improved machining properties.

The increasing use of steel containing 0·30–0·40% carbon with 1·3–1·6% manganese have been referred to. Such steels, however, lack the capability of hardening deeply. The addition of molybdenum assists deep-hardening and provides a class of steels giving very good properties. These steels are not prone to the development of surface markings in the same manner as the chromium-wearing steels, whilst the cost of the molybdenum addition is considerably less than that of the nickel content required

to give equivalent properties. These steels have been in use for a number of years and must be regarded as established steels with a reputation for reliability. The development of the higher manganese-molybdenum steels has proceeded gradually towards maximum contents of manganese and molybdenum, limitations being placed on the higher limits of manganese by troubles of manipulation. These troubles become evident with about 1·7% of manganese when the carbon is of the order of 0·40%, but by suitable adjustment of carbon and manganese, with additions of molybdenum, practically any combination of mechanical properties normally specified can be met. Tests of these steels compared favourably with those obtained from nickel-chromium-molybdenum steels which are regarded generally as the highest quality alloy steels available commercially at the moment.

## B.S.S. for Aircraft Materials

### 5 L.I.: Aluminium-Alloy Bars, Extruded Sections and Forgings

THIS replaces 4 L.I. and D.T.D. 18 C. The composition is 3·5 to 4·5% copper, 0·4 to 0·7% manganese, 0·4 to 0·7% magnesium, up to 0·7% silicon, up to 0·7% iron, up to 0·3% titanium, and the remainder aluminium. Minimum mechanical properties for fully heat-treated test-pieces are :—

| | | |
|---|---|---|
| 0·1% proof stress | .. .. | not less than 15 tons per sq. in. |
| Ultimate tensile stress | .. | ,, ,, 25 ,, ,, |
| Elongation | .. .. .. .. .. | ,, ,, 15% |

### 4 L.3: Aluminium-Alloy Sheets and Strips

This replaces 3 L.3. The composition is 3·5 to 4·5% copper, 0·4 to 0·7% manganese, 0·4 to 0·7% magnesium, not more than 0·7, 0·7, and 0·3% of silicon, iron, and titanium, respectively, and the remainder aluminium. Minimum mechanical properties for fully heat-treated test-pieces are as follows :—

| | 0·1% Proof Stress, Tons/sq. in. For Material thicker than 25 s.w.g. (0·020 in.) only. | Ultimate Tensile Stress, Tons/sq. in. | Elongation % on 2 in. For Material thicker than 12 s.w.g. (0·104 in.) only. |
|---|---|---|---|
| | Not less than | Not less than | Not less than |
| Material over 12 in. wide (transverse test).......... | 14·5 | 25 | 15 |
| Material 12 in. and under (longitudinal rest).......... | 15 | 25 | 15 |

Single and reverse bend tests are required for sheets and strips 12 s.w.g., and thinner, and an approved hardness test has also to be made. Manufacturing tolerances are specified.

### L. 38: Aluminium-Coated Aluminium-Alloy Sheets and Strips

This replaces D.T.D. 111, and covers the alloy generally known as Alclad. The composition of the alloy comprising the core of the sheets and strips is: 3·5 to 4·5% copper, 0·4 to 0·7% manganese, 0·4 to 0·7% magnesium, not more than 0·7, 0·7, and 0·3% of silicon, iron and titanium, respectively, the remainder aluminium. The composition of the coating is aluminium of purity not less than 99·7%.

Minimum mechanical properties for fully heat-treated test-pieces are: 0·1% proof stress (for sheets and strips thicker than 25 s.w.g. only), not less than 13·5 tons/sq. in.; ultimate tensile stress (all thicknesses), not less than 24 tons/sq. in.; and elongation (on 2 in.), for sheets and strips thicker than 12 s.w.g., not less than 15%. Single and reverse bend tests are required for sheets and strips 12 s.w.g. and thinner. Manufacturing tolerances are specified.

# The British Cast Iron Association

AT the recent Annual Meeting of The British Cast Iron Research Association the Council reported progress in research and development and in other activities of the Association. The statement of accounts shows that the income for the past year has been the highest yet reached, and the Council expresses the hope that the increased prosperity of the industry and the need for greater scientific knowledge in the cast iron industry will encourage further financial support.

The progress made in the research and development programme during the year is conveniently summarised in the Report under the various committees. The most fundamental investigation being conducted by the Association is that on the formation of graphite in cast iron and its modification. The process evolved for the refinement of graphite by the incorporation in the melt of a small amount of titanium and subsequent treatment of the melt by means of an oxidising gas has led up to a theoretical explanation which is given. It is noteworthy that the theory of the undissolved graphite particle as the origin of graphite flakes has been abandoned, but the nucleus theory still holds, the non-metallic inclusion now being regarded as the nucleus. The work reported on the production of fine graphite structures is expected to throw a good deal of light on the production of high quality irons of the inoculated type. This work throws into prominence the non-metallic inclusion as the focus of metallurgical interest, and the same position holds good with regard to steels and non-ferrous metals.

The work started last year by the Melting Practice Sub-Committee on the melting quality of a series of metallurgical cokes, undertaken in conjunction with the London, Midland and Scottish Railway Co., at Derby, has been completed and the data is being examined and a report prepared. It is of interest to note that 141 balanced blast cupolas are now installed or under construction with an aggregate hourly output of 1,078 tons. The situation with respect to metallurgical coke lays further stress on the importance of economy which this furnace offers.

Considerable progress has been made in an investigation on the use of certain naturally-occurring clays as bonds for moulding sands, both natural and synthetic, and a number of reports have been considered by the Sands and Refractories Sub-Committee. The problem of refractory linings for cupolas, rotary furnaces, etc., has had attention, mainly by way of examination of samples the service life of which is known.

The Tests and Specifications Sub-Committee has considered proposals involved in the revision of B.S.I. Specification 321, and has also dealt with minor investigations for the improvement in accuracy and speed of analytical methods. The revision of recommended tolerances for foundry pig iron by the Pig Iron Sub-Committee has been completed. The Sub-Committee also proposes to formulate a basis for the grading of foundry pig iron according to type. A tentative agreement respecting chill test pieces has been arrived at by the White and Chilled Iron Sub-Committee, for use in controlling production and on the effects on chill of elements of composition, pouring temperatures, etc. The Malleable Cast Iron Sub-Committee has considered work done on the impact strength of malleable cast iron and on the strength of malleable cast iron at elevated temperatures. Developments in the manufacture of malleable cast iron have been actively discussed, and the standard malleable test bar has been considered.

Investigations on combined stress, cast crankshafts, and high temperature tests, have been carried out in co-operation with the National Physical Laboratory, reports on some of which have been published.

# Non-Ferrous Metal Tubes

*It is doubtful whether the manufacture of any single product has made greater progress in recent years than non-ferrous tube manufacture, a subject which was discussed by Mr. W. L. Govier, at a recent meeting of the Midland Metallurgical Societies, and which is summarised in this article.*

THE last few years have seen rapid changes in methods of non-ferrous tube manufacture. From the viewpoint of the metallurgist and technician this has provided increased interest, as, not only have improvements and changes in plant been made, but also many new alloys have entered the field, and the story of optimum methods of producing these newer alloys in tube form with the aid of improved plant has become extremely fascinating.

Processes involved in tube manufacture can be dealt with under the following heading—casting, hot punching, piercing, extrusion, tube reducing, cold drawing and annealing. Casting can be divided into two sections—the production of shells and of billets. The former is used for direct cold drawing into tubes, whilst the latter is required for hot punching, rotary piercing or extrusion. Shell casting consists of pouring molten metal around a core, supported centrally in a cast-iron chill mould. The mould may be of split or of cannon type, and moulds of the latter class may be rotated during pouring, or remain stationary. The object of this process is to obtain solidity combined with good surfaces in a comparatively thin-walled casting, which is subject to rapid freezing. Coke-, gas- or oil-fired crucible furnaces are still largely used for this type of casting and pouring is effected directly from the crucible. Electric furnaces can also be used, when ladle pouring is usually found to be most convenient.

Most brasses, bronzes and cupro-nickels can be satisfactorily cast by this method. The aluminium brasses and bronzes form an exception, as the presence of aluminium oxide decreases the fluidity of the metal and the oxide becomes inavoidably dispersed throughout the thin section, and may give rise to fractures during the subsequent cold-drawing operation. The control of quality is achieved by fracture tests, machining of outside and inside surfaces and by density determinations.

Billets are cast in cylindrical cast-iron chill moulds of trunnion or plain type. Pouring can be carried out equally well direct from crucibles or electric furnaces or by ladle from reverbatory furnaces. De-oxidised copper, brasses, bronzes and cupro-nickels are poured into moulds coated with an oily dressing. Tough pitch copper is cast in bone-ash dressed moulds. Aluminium brasses and bronzes are poured into moulds without application of dressing, since aluminium oxide formed on the surface of the molten metal prevents adherence to the mould surface. The well-known Durville method of casting is used for these alloys.

The chief defects to which billets are liable are surface troubles, sub-surface unsoundness, general unsoundness and piping. Billets are handled in full length in the hot-punching and piercing operations, but are sawn into short pieces for extrusion, the gates and sometimes the bottom ends, being excluded.

Perhaps the oldest hot-working process for the production of shells from solid billets consist of the use of a hydraulic ram which forms a piercing bar and which is forced into the middle of a billet held in a container. As far as de-oxidised copper shells are concerned, this process has been superseded by the rotary-piercing process, but the hot-piercing or pushing process is still used for the manufacture of very large tubes, particularly in alloys which will not withstand the drastic hot work applied by rotary piercers. Presses may be horizontal, or vertical, and the latter are usually preferred. The operation is one of displacement, and resembles inverted extrusion.

An important step forward in the manufacture of copper tubes was achieved when, some thirty years ago in England, the rotary piercer was introduced. The machines in present use for the manufacture of copper shells from cast billets are chiefly of the Evans type. The piercing operation is rapid and does not involve the use of costly tools. One machine can deal with a large range of billets, from $2\frac{1}{2}$–5 in. on a small machine. Copper is usually quenched in water immediately after leaving the machine, and this treatment removes practically all of the scale. Various alloys have been successfully pierced. Those which are well-known hot-working materials—*e.g.*, the alpha beta brasses, can be pierced with comparative ease. Aluminium bronze and cupro-nickels of low-nickel content can also be worked on this machine, but many alloys which can be extruded with ease cannot be successfully pierced.

The extrusion process is still being developed as far as tube work is concerned. The advent of the tube extrusion press has enabled many alloys, which previously could not be hot worked or only with great difficulty, to be converted from castings to shells from which finished tubes can be made with comparatively little drawing. Admiralty and 70/30 brass and certain phosphor bronzes may be mentioned in this connection. Also, alloys which are difficult to cast, or which are drawn with difficulty, or need a considerable number of light drafts, can often be readily extruded near to finished sizes. Aluminium brass and bronzes which, as mentioned, cannot be cast satisfactorily in shell form, are readily cast as billets by the Durville process and extruded. It may be said generally that tubes made by the extrusion process are of better and more uniform quality than those drawn directly from shell castings.

Tube reducing as applied to the cold working of non-ferrous metal tubes is of comparatively recent date and improvements in machines are still being made. The principles and methods of operation are incorporated in the white-tube reducing machines which are in operation in America, on the Continent, and also in this country. A comparison of the microstructure of reduced tubes with those of drawn tubes has shown that the former tubes possess certain structural characteristics which are due to the severe work and to its method of application. The tube reducing process is essentially different in that it employs mostly compressive stresses instead of mostly tensional stresses as in the drawing operation. Certain points, many of which will doubtless be overcome affect the economic aspect of this process. The production of dies involves the use of a special die-making machine, and the machining, grinding and hardening of dies are operations requiring great skill to ensure that dies are of perfect fit and capable of long life.

After shells have been made, the finished tube is produced by cold drawing. The drawing operation is usually carried out on push benches, or chain benches. Large and heavy tubes are dealt with in the early stages of drawing on push benches, while the bulk of tube drawing is effected on chain benches. Usually three types of drawing operations are performed on chain benches—*viz.*, mandrel-bar drawing, plug drawing, and hollow sinking. It is not easy to propound any hard and fast rule regarding the choice between the first two methods. Hollow sinking consists of drawing a tube through a die without any internal support. Reduction in diameter occurs, but the change in

thickness is dependent on the ratio of diameter to thickness, is dependent on the ratio of diameter to thickness, shape of die, the material and its condition when being drawn. A relatively thin tube will increase in thickness during this operation, but a heavy-walled tube may become thinner, as flow of the outside surface will occur.

Plug drawing is usually employed for tubes of small bore and relatively great wall thickness. The large pinches which can be applied with mandrel bars are not obtainable with plugs. Incorrect drafting is liable to leave internal stressed in a tube, which may give rise to season cracking. This tendency is always present in hollow-sunk tubes. In order to detect the presence of serious internal stress, the well-known mercurous nitrate test is usually applied, though some caution should be used in its application.

Two of the most important desiderata in the tube mill are cleanliness and accuracy in working with respect to dimensions. The latter point is obvious and demands constant attention from foremen and operatives, with regard to wear of tools, use of correct tools, etc.

As regards the future, the rotary-piercing process has by no means been exploited to its fullest capabilities with regard to tube manufacture. The extrusion press is still being developed with regard to improved concentricity, heavier shells and increased diameters. Tube-reducing plant will increasingly supersede the draw bench as mechanical improvements are made. The large amounts of cold work which can be performed by the tube-reducing machine gives rise to thoughts concerning how much cold work can be applied to a metal or alloy if only it is applied in the right way. The process of continuous casting and reducing, although at present only just achieved, has interesting possibilities.

## Mineral Developments in Okanagan Kettle River Area, British Columbia

Despite the relatively low price of silver, the properties on Wallace mountain are in steady production, with some of them reporting a considerable profit from operations. The ores have a silver content ranging from 100 oz.to 300 oz. a ton more. Highland Bell, the largest producer, is carrying out an exploration and development programme on the Sally property, a major producer in the past.

Two discoveries have been made near the headwaters of Lambley creek and Nicola river in the West Okanagan lake section, one of them a copper showing with gold values, and the other carrying values in silver, lead and zinc. Sulphide bodies with gold values have been exposed in the valley of Peachland creek, near its junction with Greata creek.

Kelowna Exploration Company, is mining the old nickel-plate workings in the Hedley camp. Hedley Mascot Gold Mines is in steady production with an output of 150 tons a day, and is making a geological examination of its holdings on Nickel Plate mountain. Hedley Amalgamated is crosscutting in an attempt to locate the probable downward extension of an orebody disclosed by drilling last year. A drilling programme is under way at the Golden Zone property.

The Fairview and Morning Star properties in the Penticton-Osoyoos area have been amalgamated, and the ore is being treated in the reconditioned Morning Star mill. Mining is proceeding on a small scale at the Twin Lakes property, and development work is under way at the Golden Valley mine.

Considerable placer and lode gold activity is reported from the northern portion of the Okanagan area, mainly in the vicinity of Vernon. Little information is available on a placer discovery reported to have been made east of Vernon on Harris Creek.

## The Steel-Tube Economiser

### Interesting Installation at Deptford Power Station

EXTENSIONS now in hand at the Deptford West station include an installation of "Foster" steel-tube steaming economisers which has a number of interesting features, especially as regards efficiency, easy inspection and cleaning, and heat insulation. Further, there are also two "Thompson" boilers of 300,000 lb. per hour maximum continuous evaporation, to operate at 370 lb. per sq. in. gauge and 780° F., with superheaters, and air heaters, as well as the economisers and also multiple-retort stokers, vane control, induced and forced-draught fans, and centrifugal-grit arrestors. Also the boilers are each of 21,723 sq. ft. heating surface, along with 4,346 sq. in. bore steel tube combustion chamber walls, while the superheaters are 8,000 sq. ft.

The "Foster" economisers for each boiler, supplied by E. Green and Son, Ltd., Wakefield, are 15,120 sq. ft. heating surface, composed of 168 tube elements, 14 ft. wide, 12 ft. high, and 30 ft. long, formed as usual of steel tubes separately supported in tube plates, with cast-iron gills shrunk on the outside, which results in a greatly increased rate of heat transmission, whilst eliminating external corrosion. Operating conditions of the economiser will be, at the maximum duty of 300,000 lb. evaporation per boiler per hour, a reduction in the combustion gases from 840° F.–552° F. (entering the air heater). This corresponds to a rise in the feed water from 240° F.–343° F., whilst the frictional drop in the draught is 0·75 in. W.G., and in the water pressure through the economiser 3 lb. per sq. in. When operating under the more normal conditions of 240,000 lb. of water evaporated per hour the conditions will be combustion gas entering the economiser 760° F. and leaving 494° F., with 240° F. in the feed water before and 334° F. after, along with 0·5 in. W.G. drop in the draught and 2 lb. per sq. in. drop in water pressure.

The casing surrounding the economisers is of a special construction consisting of an inner casing of lift-off panels, which are covered with heat-insulating material, and an outer casing of hinged doors with no metallic contact between. Consequently a non-conducting air space is formed which results in a negligible loss of heat by radiation, while the inside dimensions of the inner or main casing are 30 ft. 7¼ in. long, 12 ft. 4 in. high, and 7 ft. 3½ in. wide.

In addition, the lift-off panel can be removed and replaced in a few minutes, thus ensuring easy and rapid soot removal. Each group of tubes also is provided with soot blowers underneath having an arrangement of deflecting hoppers so that deposits blown off any part of the tubes cannot return to another part of the tube surface. Ample provision is made for expansion at both the inlet and outlet water connections, including gland rings for the end plates with spring-contact asbestos packing, so that most severe fluctuations in the heating conditions and evaporation, from 150,000–300,000 lb. per boiler per hour will cause no difficulty. Space also has been left for the addition of more economiser surface should the duty increase at any future time.

It may be stated the four "Thompson" boilers now operating at Deptford West, each of 160,000 lb. per hour normal evaporation and 200,000 lb. overload, are also equipped with "Foster" economisers.

## Soviet Niobium and Tantalum

It is reported from Sverdlovsk that according to a statement made by the Institute of Geology and Mineralogy in the Urals, the Selyankin deposits of ore containing niobium and tantalum are of great industrial importance. The Institute is now working out a process for the technological treatment of these ores, and it is hoped that the Soviet Union will soon be in a position to produce its own niobium and tantalum. Both these rare metals are used in the production of stainless steel.

# Straightening Tubes and Round Bars

*Despite progress in the development of mechanical devices for straightening tubes and bars, crude methods still find favour, but for high-speed production modern methods of straightening are essential, and in this article some machines are described.*

WHAT may appear, to those unacquainted with the intricacies and problems of the bright-drawn bar and seamless-tube trades, to be archaic and crude methods still find favour, especially in regard to the straightening of delicate small diameter tubes with walls of 16 or 18 I.W.G. thickness in various non-ferrous alloys, stainless and carbon steel. Springing by hand pressure to remove kinks and distortion from exact straightness has been practised since the inception of the tube trade, and its principle is illustrated at Fig. 1. To become an expert "springer" or straightener takes years of practice, and the really competent operator is regarded as being of much more value than the expert drawbench hand.

Few will remember the state of affairs at the Mannesmann Tube Co., Ltd., Landore, in the early days of its inception, when 75% of a huge output of bicycle tubes were sent to America. This was during the period when R. C. Stiefels, of piercing mill fame, was employed as work's manager. At that time, in addition to sending finished tubes to U.S.A., the firm despatched hundreds of tons of hollow blooms per month, which were finished into tubes by the Americans. R. C. Stiefels subsequently, in 1896, disposed of his patents to a Pittsburgh firm, and Great Britain lost a wonderful market for steel seamless tubes.

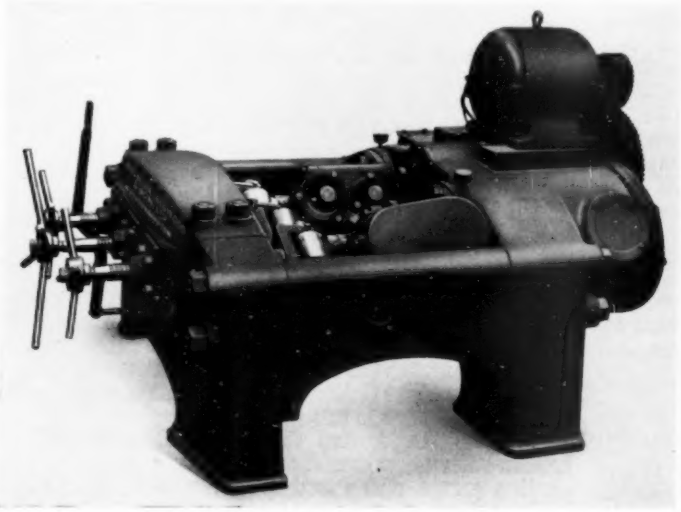

*Fig. 2.—A small straightening machine with axially adjustable driving rolls.*

Reverting to straightening, the operators most sought after, in the early days, were a competent gang of springers. Birmingham was the source of supply of labour of all classes in connection with the trade, and every effort was made to stop the migration of these trade pioneers ; but the wages offered by the German works of Ralph, Carl and Max Mannesmann overcame all scruples, and the pick of the trade were moved lock stock and barrel at the company's expense. The piece work on straightening was at a low figure per 100 ft., but the colossal sums earned by these springers imported from Birmingham were regarded with awe.

After a long experience in the ferrous and non-ferrous seamless tube trade, the writer still has a high regard for the art of the springer, even though one's opinion has been modified after having made an intensive test and examination of plant specially designed and built for the purpose by Joshua Bigwood and Son, Ltd., Wolverhampton. This machine is based on the cross-roll principle of the reeling machine, a principle which also governs all designs of rotary-piercing mills—*viz.*, Mannesmann, Stiefels, Diescher and the Evans. Among many appealing features it is

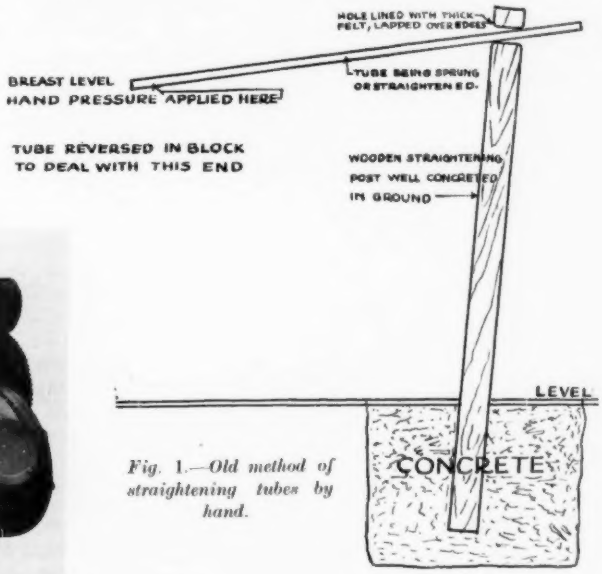


*Fig. 1.—Old method of straightening tubes by hand.*

interesting to note that in this modern type, one set of rolls only is direct power driven, and these rolls are adjustable axially, which arrangement ensures a perfect line of contact on whatever size of material the mill is set up to deal with. Fig. 2, shows one of the heavier types made with a capacity to deal with tubes up to 6·5/8 in. diameter or solid bars up to 4 in. diameter

The operation of this machine is simple. After selecting the stock to be straightened, the rolls are opened so that the tubes or bars can be pushed into the machine. The three idle rollers are then brought up against the bar. The motor is started and the bar backed out so that the front end of the bar is at the back of the middle idle roll. Adjustment is then given to the middle and end idle rolls, the motor is started, and the machine will straighten continuously for the same size stock. With this machine any bar or tube can be straightened within its capacity from 3–100 ft. in length at a speed of 100–225 ft. per minute.

For the purpose of comparison, a smaller machine of similar type is shown in Fig. 3. This machine also embodies the most recent improvements in design, and in particular the axially-adjustable driving rolls, thus ensuring a perfect line contact for whatever diameter of material the machine is set up to handle. It will straighten up to 3¼-in. tube and 2¼-in. bar.

As an investigator into claims which covered such a wide area, the writer possessed, at the outset of the demonstrations, of an open mind, though perhaps somewhat sceptical and while still holding the same opinion with regard to the human springer mentioned earlier, is now definitely

of the opinion that the plant under review can deal efficiently with what constituted one of the biggest problems of the seamless-tube manufacturers—*viz.*, kinks and bows in the length of the finished tube. Noteworthy features are the remarkable robustness of the machine, and its simplicity of control, and there is no hesitation in classing it, when once set, as fool-proof, even when in charge of unskilled labour.

Following the demonstrations, inquiries were made regarding the value of this type of machine in practice, and by the courtesy of the management access was given to recorded reports as to the success of these tube and bar straighteners. Time did not permit a perusal of all correspondence available, but it is possible to record that these machines have been successfully adopted by 48 firms in Great Britain, 65 firms spreading from Italy to Norway and Sweden, from Russia to France and Spain, and others as far away as the United States of America, Japan and Australia.

# Tin Researches

### The Spectrographic Analysis of Tin

WORK on the spectrographic analysis of tin, carried out by the British Non-ferrous Metals Research Association, has now been extended to include the quantitative determination of aluminium, cadmium, and zinc in tin. The report of the investigation by D. M. Smith, B.Sc., A.R.C.S., D.I.C., is divided into four sections. Section I gives a summary of previously published work on the spectrographic analysis of tin. Section II deals fully with the determination of small amounts of aluminium, cadmium and zinc, and contains the greater part of the new work. A revision of the analytical tables for the determination of impurities in tin by means of spark spectra, photographed under the standard conditions previously adopted, forms the subject matter of Section III. Section IV gives a general summary of the work done on the spectrographic analysis of tin, and the conclusions reached with regard to technique and analytical methods.

Arc and spark methods were investigated for the quantitative determination of impurities in tin over the range from 0·001 to 1·0%. As an appendix to the paper, there is a description of the electrolytic method of refining tin in the laboratory for the purposes of obtaining spectrographically pure tin for use in the preparation of standard alloys containing very small amounts of the alloying constituents.

### Opacification of Enamels with Tin Oxide

Stannic oxide is one of the oldest and most used of enamel opacifiers, and because of its suitability for every class of enamel it has received little attention in the technical literature as compared with its substitutes since the conditions under which they are practicable have needed more careful investigation. This publication is an account in English of investigations by Dr. Ludwig Stuckert, which were read before the Society of German Enamel Technologists.

The effect of opacifiers on the enamel is not confined to optical differences, but is productive of physical and chemical changes which have important influences on the properties of the enamels. The influence of opacifiers was investigated for both wet and dry enamels, in respect of the coating power of the enamel, its bending strength and heat resistance, its solubility on extraction with dilute acids and the opacity and lustre after normal burning and overburning.

In firing enamels there is more than a mere enveloping and penetration of the opacifier particles and occasional dissolution and vitrification of them. Stannic oxide on the whole exerts the most beneficial effects on the properties of the enamel, improving not only the coating power of the enamel, but also mechanical, thermal and chemical properties to a greater extent than any other opacifier. Stannic oxide enamels are stable towards firing and over-firing and do not "boil out" or become foamy, and the superiority of stannic oxide as regards the gloss of the enamel has also been confirmed. The ease of its application and the reliability of its opacification, added to the newly-discovered benefits it confers on the enamel in physical and chemical respects, ensure for it the leading place among opacifiers.

### Micro-plasticity in Crystals of Tin

A paper by Bruce Chalmers, B.Sc., Ph.D., on the above subject, is published in the August issue of the proceedings of the Royal Society. It has now been issued as a separate publication. Many problems relating to the fundamental properties of the metallic state can best be approached through experimental investigations on single crystals of metals. In this investigation the nature and characteristics of the yield point were examined to find out whether the value obtained for the yield point is real or a function of the accuracy of measurement. The relations between tension, length and time for single crystals of tin of high purity were measured by an optical interference method. A number of new phenomena have been noticed, notably plasticity below the accepted yield point, and called by the author "micro-plasticity." The results are discussed in relation to slip and distortion in the crystal space lattices.

Copies of the above publications may be obtained free of charge from the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C. 2.

# High-strength Sand- and Die-casting Aluminium Alloy

A HIGH-TENSILE sand- and die-casting aluminium alloy known as "Hiduminium" R.R. 53C, has been developed from the R.R. 50 and R.R. 53B alloys, which latter alloy it now supersedes, and combines the good casting properties of the former with the high tensile properties and ductility of the latter. The fluidity of this new alloy, in the molten state, is such that it can be cast in very intricate forms, while its strength and feeding qualities through the solidification range considerably reduce any risk of solidification cracks and porosity previously encountered in high-tensile casting alloys when cast in intricate forms.

When solid, this alloy has strength and ductility superior to R.R. 53B, enabling it to be quenched after solution treatment without fear of cracking caused by uneven contraction of various sections, hence, even with complicated castings the highest tensile properties may be obtained. It is not, however, recommended for use in parts subjected to temperatures above 200° C., such as pistons and air-cooled cylinder heads. In this field R.R. 53 is still considered to be superior.

The solution treatment of this new alloy consists of a heating period of two to six hours at 530° C., followed by a quench. The ageing treatment is carried out at 165° C. for a period of 15 to 20 hours. After this latter treatment it may either be quenched or allowed to cool in air.

MECHANICAL PROPERTIES OF R.R. 53 C.

Tensile tests on bars cast to 1 in. diameter in B.S.I. sand lined-mould and machined to 0·564 in. diameter.

| Condition. | 0·1% Proof Stress, Tons per Sq. In. | Ultimate Stress, Tons per Sq. In. | Elongation % on 2 in. | Brinell Hardness No. |
|---|---|---|---|---|
| As cast | 5—6 | 10—12 | 2—3 | 60—68 |
| Solution treated | 9—10 | 14—15 | 2·5—3 | 70—75 |
| Solution treated and aged | 18—20 | 19—22 | 1—2 | 100—115 |

Tensile tests on chill cast bars 1 in. diameter. Machined to 0·564 in. diameter.

| | | | | |
|---|---|---|---|---|
| As cast | 6·5—7 | 11—13 | 2—3 | 65—70 |
| Solution treated | 10—12 | 17—19 | 2—3 | 75—85 |
| Solution treated and aged | 19—21 | 22—24 | 1—2 | 110—121 |

# Utilising Brass Slags

By C. C. DOWNIE

*A process is described for utilising brass slags, after the brass values have been recovered, which is claimed to be profitable. The method of recovering the brass values is discussed.*

THE usual process for recovering brass values from reverberatory slags consists in grinding them, and passing the ground mass through a series of jigs, and finally on to a washing table. The same method is adopted for dealing with brass ashes, except that the latter, being of a softer nature, lend themselves to a simpler form of grinding. Brass slags from the reverberatory furnace are generally skimmed off indiscriminately into a pit, or hole, in close proximity to the furnace. When solidified, such lumps are large and unwieldy, and usually require to be broken with the hammer, or passed through a jaw-breaker prior to grinding. In many works, the recovery process is considered to be uneconomical, but where the slags show a tendency to be viscous, the amount of metal contained by them may be considerable.

Fluxes which could make the slag more thin and fluid are seldom considered, as the object of the work is to provide brass for founding purposes. Where much scrap is used in the charges, more scale is generally present, and the amount of metal-laden slag is increased. Experienced furnace attendants often prefer to have a good covering of slag, as by so doing the amount of metal volatilised is thus reduced.

Certain designs of reverberatory furnaces constructed specifically for dealing with light scrap, make provision for the slag, which is expected to be rich in metal values. In one of these designs, the scrap brass is melted on the sloping hearth in the usual manner, but when the slag is removed from the surface of the mass (when it has reached the bath, or "well") it passes into a small adjoining bath. This latter is kept heated by an independent fire, and is conical in shape. What metallic contents remain in the slag are given the opportunity to separate to the bottom, and are later tapped off, in the same manner as is done in smelting furnaces. So far as the ordinary reverberatory brass furnace is concerned, no such provisions are made, with the result that quite an appreciable amount of metal is lost in the slag.

It has often been suggested that these slags might be smelted, but the costs have generally vetoed practical application. Where the slags come from gun-metals or other alloys rich in copper, the content of the latter metal is, of course, much higher. Incidentally, the proportion of zinc is lower, and accordingly, the slag is more easily fusible. Ordinary yellow brass, or Muntz metal, may contain approximately 40% of zinc, and although this addition of zinc may be made at the final stages, much of it is absorbed by the slag in the form of zinc silicate. The latter compound is exceedingly infusible, and raises the melting-point of what might otherwise have been a very fluid slag.

When it comes to re-melting such slags, this infusible characteristic becomes more pronounced. Usually the smelter makes a wide study of the composition and physical properties of the slag, but the same cannot be said of the average brass-founder. As a general rule, the founder takes the slag which he gets, without making any attempt to alter the composition, in order that nothing can adversely affect the soundness of the brass to be cast.

When contemplating the direct recovery of the brass from these slags, it is considered a good plan to discriminate between those recovered from ordinary yellow brass and those obtained from richer copper alloys. By making a suitable mixture of the two, the amount of the infusible constituent, namely, zinc silicate, is thus reduced. It has been proposed to simply melt the slag in a cupola, and, by working at a higher temperature, to allow the metal values to separate out, but, unless the content of zinc silicate is low, much trouble is likely to be experienced. As some slags are exceedingly low in brass, the process of recovery would not be a paying proposition, unless some use can be found for the final cupola slag. By working in this manner, the same attention need not be given to the composition of the respective raw products. For example, in one works where this reclamation process was used, all kinds of slags were sampled and analysed, and those poor in brass were rejected. But this led to a considerable amount of expense for the analysis conducted. It is considered a much better policy to be able to deal with all descriptions of slags, irrespective of the metal content, as by so doing the process could be kept in operation for indefinite periods.

### The Reclamation Process

The following process was successfully used by one firm who collected brass slags from a wide variety of founding firms. No efforts were spared in securing the best possible furnace conditions, to ensure that the mass always was converted to a thin fluid. The process was not at first used as a brass-reclamation system, but simply as a means of preparing blocks for building purposes.

The slag was rendered fluid by additions of other slags, and cheap fluxes, such as fluorspar, tannery-lime, and certain wastes from alkali works. The oxygen ratio of acid to bases was carefully followed, and efforts made to see that the resulting product was represented by a bi-silicate. The presence of too much alkali matter is disadvantageous, as a light alkali silicate generally separates out on the top of the cast slag. Incidentally, building blocks are expected to withstand all kinds of weather conditions, and the presence of alkali tends to weaken the crystalline structure, apart from a slight disposition towards decomposition.

One outstanding feature about this work is that the slags do not require to be subjected to any preliminary breaking, or grinding process, as opposed to the usual washing, or vanning-table systems. So long as the lumps can be thrust inside the cupola door they suffice for this work.

One of the most objectionable impurities found present is carbon. Strange though it may appear, this impurity cannot be readily fluxed, unless expensive oxidising agents are employed. The carbon separates out in different sections of the blocks cast, and makes them unsightly. It should be understood that blocks made from slags are best used in conjunction with other concrete blocks of more artistic appearance. The dark, or black appearance of the slag block, although often lustrous, is at times thought to be sombre, and not suitable for general housing purposes, although quite acceptable for foundation work. The well-fused mass is strong, rigid, and consistent throughout, and hence the need for carefully regulating the melting conditions.

Instead of allowing the metallic brass to separate out by gravity, a much more complete separation can be made by adding pyrites, as is done in cleaning copper refinery slags. The iron from the pyrites is partly oxidised, and joins the slag, making it more fusible. When this addition has been too considerable, the matte produced is poor in copper, but in such cases is returned to the next charge, when it picks up more copper. By working in this manner, any oxidised copper present in the slag is fully recovered, whereas in the direct settling, or separating process, all oxidised copper is lost. This matte is sold to either smelting firms, or makers of copper sulphate.

When used for the latter purpose, the amount of zinc present has to be considered. The matte is roasted at 750° C., whereby both copper and zinc are converted to oxides. When dissolved in dilute sulphuric acid, and evaporated, the zinc sulphate separates out completely from the copper sulphate. The operation of the crystalling process requires a certain amount of skill, but is done outside the precincts of the reclamation of the brass slags. The process depends on the fact that the iron sulphide is converted to ferric oxide at 530° C., and remains insoluble in the dilute acid used. The roasting converts the copper and zinc sulphides first to sulphates, and then to oxides, the copper at 650° C., and the zinc at 740° C. In solution, copper sulphate separates out at 73%, and zinc sulphate at 95%, which thus makes a good separation.

### Use of Cupola

When operating the cupola, the slags are charged with their necessary additions to render them fluid, and the matte tapped from the bottom after a sufficiency has collected. The slag runs practically continuously from the slag spout. An ordinary iron-founder's cupola is used, and no water-jackets, such as are required in blast-furnaces, are necessary. The molten slag is run into moulds of oblong dimensions, whereby the product is suitable for building purposes. The moulds are made of iron, and the walls are faced with a mixture of fine carbon and fireclay. This mixture is made up as a wash, and applied with a brush. The molten slag sets in the mould, and gives a true representation of the shape, whilst the carbon prevents any sections from adhering to the sides.

The fireclay in the mixture is only used to ensure that the carbon will remain in position on the walls of the mould. (Waterglass was used as a substitute for the fireclay, but was not successful, as it imparted a frosted appearance to the dark sides of the blocks.)

An alternative system of working consisted of using a small proportion of metallic iron in place of the iron pyrites. This iron assisted in precipitating the brass in metallic condition, but the extraction of the copper is never so complete as when pyrites are used.

It should be understood that the recovery of the metal is regarded as a supplementary process, and the principle object is the production of building blocks. Other slags are not so suitable for this purpose. For example, ordinary cupola or iron blast-furnace slags contain too much metallic iron, on odd occasions, to be of practical use, and the addition of pyrites would provide a literally useless product. This uncertain presence of metallic iron makes it practically imperative to adhere to brass slags only.

The blocks are not brittle, as might be suspected, but are tough and rigid, particularly where fluorspar has been used as the flux addition. The earlier suggestion that fluorspar would injure the walls and linings of cupolas has proved in practice to be unwarranted. The moulds for the blocks are placed on bogies, and wheeled up to the spout of the cupola as required.

Tests made of the blocks, and compared with those made from ground slags and cement, showed they were superior in all physical respects, whilst the dark colour was the onlyfeature which could be held against them.

## Manufacture of Sporting Cartridges and Copper Tubes

CARTRIDGE brass, the alloy used in the manufacture of cartridge heads, said Mr. H. O. Smeldon, in a recent lecture on the above subjects, contains 70% copper and 30% zinc, and the casting of ingots weighing ½ ton each, and their rolling down to strip $\frac{2}{1000}$ in. thick, at the Witton works of Imperial Chemical Industries, was illustrated in a short film. Mr. Smeldon dealt with the methods in which the strip is worked up into the brass head, the cap chamber, and the anvil, and mentioned the careful visual inspection which is carried out before the heads are ready to be assembled.

### Seamless Copper Tubes

Although far removed from cartridge manufacture, the manufacture of solid-drawn seamless copper tubes at the works of I.C.I. Metals is carried out with similar accuracy and precision. The lecturer referred to the rapidity with which such tubes were replacing pipes of iron and lead, notably for domestic gas and water services, and to their salient advantages in use—such as their non-rusting qualities, the impossibility of formation of poisonous products by the passage of water, smoothness of bore, high water delivery in proportion to size, lightness, and ease of bending. Also, he said, they were much less likely to burst in frosty weather.

At Witton the copper for making the billets for piercing is melted in electric furnaces, a method which makes possible the control of melting and pouring operations within narrow limits, and ensures a high degree of purity in the finished product. The lecturer described the setting up of the billet moulds, and the rotary piercing of the billets, which takes only a few seconds in an improved type of machine. The resulting "shells" are cold-drawn down to tube size by a mandrel method, which was described in technical detail.

After annealing and pickling, the finished tubes are subjected to hydraulic pressure four or five times greater than that likely to be required under working conditions. They are finished to a special temper which strikes a balance between mechanical rigidity and ease of bending without annealing.

### A New Copper Conduit

In conclusion, Mr. Smeldon touched briefly upon one of the most recent and important advances in non-ferrous metal manufacture, namely, the production of non-screwing copper tubes for electric wiring systems. The new system, known as the "Broduit" system, involves the use of light-gauge copper tubes, which can be simply joined by unscrewed copper couplers, and which make possible the installation of a non-corrodible electrical conduit, which is more easily handled than iron conduit, and ensures greater mechanical and electrical continuity. Many contractors have testified that the slightly higher first cost of this new system is more than outweighed by the reduced labour costs required in its installation.

## Pearlitic Malleable Cast Iron

It is claimed that pearlitic malleables are capable of systematic subdivision for the purpose of study and discussion. They may be classified into two major divisions: Metal produced by interrupting graphitisation before completion, and metal produced by reheating completely graphitised alloys. In either division metals can be produced in which the combined carbon is present in various metallographic forms, as for example martensite, sorbite, laminated pearlite, granulated pearlite produced from the laminated variety by surface tension forces, and spheroidized structures produced by the heat treatment of the martensitic and sorbitic forms to produce coalescence of cementite particles. Each of these may constitute a group.

## Steels for use at High Temperatures

### Electrical Industries Research Conference

THE British Electrical and Allied Industries Research Association recently held a conference to discuss the future position of the research into steels which was inaugurated as a result of a similar conference held three years ago, the work having continued in the meantime at the National Physical Laboratory. Sir Harold Hartley, in opening the conference, referred to Sir Alfred Ewing, who has contributed so much to the development of engineering science, and commented on the note of pessimism in which he ended the James Forrest Lecture in 1928 on "The Century's Inventions." At that time Sir Alfred said he was a little doubtful whether engineering in the next century would show anything like the same pace in improvement and progress that it had shown in the last century. Sir Harold suggested that one of the things responsible for this statement was the question of limits of materials which would be available to engineers and which impose restrictions on engineering development.

This problem of steels for use at high temperatures is perhaps one of the most serious which the engineer has to meet to-day, especially in view of the fact that he desires to take advantage of the superior thermo-dynamic properties of substances possible from the use of higher pressures and higher temperatures. About eight years ago the Electrical Research Association recognised the urgency of this problem and, with assistance, started co-operative research. In order to accelerate this research and get it on a wider financial basis a conference was held three years ago.

Since that Conference was held a considerable measure of progress has been made and a large amount of excellent fundamental experimental work has added greatly to the knowledge of the properties of these high temperature steels.

The recent Conference was held to discuss the future of research based on the work which had been accomplished. When the work started engineers were getting very near to the limits of the properties of materials under the very strenuous conditions imposed, and Sir Harold Hartley considered it of the greatest importance that this work should continue. He directed attention to the extraordinary properties of alloys which had been developed for these conditions and the remarkable variations resulting from comparatively small differences of composition or treatment, which makes exact knowledge of the highest importance to the engineer and designer.

Sir Leonard Pearce, in emphasising the vital importance of this research work in connection with the efficiency and operation of high-pressure steam power plants, indicated one or two directions in which it seemed to him that further research work might take place. It is taking place at the present time but it might be accelerated. He referred in the first place to intercrystalline cracking under elevated temperature conditions, and secondly to the influence of spheroidisation and the corrective effects of alloying elements and heat treatment. Another important point mentioned is the correlation of test results with their practical application, taking into account cycles of heating and cooling, fluctuation of working temperatures, intermittent service and corrosion in the media in which the material serves, whether it is steam or flue gases. Finally, he mentioned the problems of oxidation, embrittlement, and ordinary thermal growth which are important aspects intrinsically associated with high temperature work.

Support for further research was expressed by Dr. W. H. Hatfield, who said that there is sufficient data available as regards materials for use up to 550° C., largely due to the work of the Electrical Research Committee, to determine what the rate of creep is for a given steel at a given temperature. To unify that and bring it to a rate of creep of one-millionth in. per in. per hour, it would be possible to postulate the stress produced at the rate of creep; but what the designing engineers want to know is what is the safe limit of stress and rate of creep, because the rate of creep and the safe range of stress are different values. He confirmed Mr. Bailey's views that a great deal of the resources available should be concentrated on exploring and further determining the safe range of stress as distinct from a specific rate of creep. If that can be done for those materials which are available, it will be a very valuable piece of work. The average performance expected in recent installations is vastly below the best of the materials which are at present available, but, said Dr. Hatfield, there is a difficulty in applying these materials because at present it is only possible to argue in an empirical manner from an arbitrary rate of creep to a safe rate of stress as regards evaluating the materials. On the other hand, the designing engineer is dealing with a complex stress instead of the more simple form of stress utilised in experiments and he also has to deal with the temperatures actually existing in his plant. He suggested that if the engineer would say the actual temperatures to be dealt with it would save a lot of trouble and lead to greater efficiency.

Various aspects of the problem were discussed by various members including Mr. A. J. Grant, Mr. W. D. Heck, Mr. Guy, Admiral W. M. Whayman, Dr. C. H. Desch, Mr. W. B. Woodhouse and Sir William Larke, and all expressed the opinion that the work should be expedited.

## Alloy Metals Review

High Speed Steel Alloys, Ltd., have published the first issue of Alloy Metals Review, succeeding issues of which will be published on alternate months. The object is to provide information on the application of alloy metals to ferrous and non-ferrous metallurgy and generally to keep readers in touch with recent developments. The first issue contains 12 pages of notes on developments and references to research work. The information is given in a condensed form and among the subjects discussed mention may be made of "Sintered Metal Powders," "Molybdenum Alloy Steels in Aero Engines," "Controlled Grain Size," "The Influence of Vanadium on Nickel-Chromium and Nickel-Chromium-Molybdenum Steels," "Molybdenum and Tungsten in Magnet Steels and Alloys," "The Influence of Manganese and Molybdenum Additions to Cast Iron," and a number of other informative items including abstracts and references of recent research work. The information is presented in a lucid form and the Review should prove useful to all who use or make ferrous or non-ferrous alloys and to those who are interested in powder metallurgy.

A copy of this Review will be sent to all interested on application to the publishers, High Speed Steel Alloys, Ltd., Ditton Road, Widnes, Lancashire, England.

## New Rolling Mill and Extrusion Works in Birmingham

Another new works will, in the early part of next year, be added to the multifarious products of the City of Birmingham. Messrs. Birmetals, Ltd., a subsidiary company of Birmid Industries, Ltd., have recently purchased a very large estate at Woodgate, near Quinton, and building operations have commenced on a portion of it for the construction of modern works.

The immediate layout, including laboratories and offices, will cover approximately 310,000 sq. ft., and will be equipped with the latest design of rolling-mill plant, extrusion, presses electric furnaces, electrical and mechanical plant, etc., for the production of high-tensile aluminium and magnesium-alloy sheets, also extrusions and drawn sections in the same alloys. Adjacent to the works a large metallurgical and physical-laboratory will be built, and will contain the scientific equipment necessary for research anf production work.

The manufacturing processes of the above products demands that a very high order of cleanliness is maintained throughout the works, and consequentlyit was essential to obtain a site with an atmosphere as clean as possible, and free from possibility of contamination by discharges from surrounding factories.

# Business Notes and News

## New Process to Reduce Cylinder Wear

Developments in overcoming excessive cylinder wear are indicated by what is claimed to be a new process on which Messrs. R. A. Lister and Co., of Dursley have been working for some time. The process, which has been registered under the name of "Listard" is said to increase the resistance to wear in Diesel engine cylinders as much as 400%. It is based on a Dutch invention brought to the Company, on which independent research and experiments were carried out. The process consists in depositing a coating of chromium on the cast-iron cylinder bore.

Investigations were carried to determine the most suitable cast iron for the purpose. It was found that cylinders hardened by the nitrogen process were unsuitable for the chromium coating. After the cylinders had received a chromium deposit, the most suitable class of finish was determined by repeated experiments. Simultaneously tests were carried out, until ultimately what was considered to be the best surface finish—that is the surface with the best wearing capacity—became standard practice.

A number of these "Listard" cylinders are now under practical test in various parts of the country, and periodical inspections which have so far been made show good results.



## Development on Tyneside

Over £3,500,000 is being spent on schemes for the improvement and extension of new industrial facilities in the Tyneside area, according to the latest report of the Tyneside Industrial Development Board. Approximately £1,500,000 is to be spent on the Team Valley trading estate, sponsored by the Government at Gateshead, and £1,350,000 is the estimated cost of the new deep-water quay to be constructed at Tyne Dock by the River Tyne Improvement Commission. Riverside improvements at South Shields will cost £152,045, to which the Commissioner for Special Areas will contribute £100,000. Newcastle Corporation is building a quay extension, to cost approximately £60,000, and the Tyne Improvement Commission is to spend £40,000 on a new quay at North Shields, to accommodate the increasing Norwegian traffic.

The London and North Eastern Railway is engaged upon a scheme for electrification of the railway on the south bank of the Tyne, and three new works are being built—a flour mill, a plywood factory, and a cable factory.

According to Sir John Jarvis, Jarrow is to have a new tube industry. It is understood that plans for the establishment of a tube mill have been completed, and an agreement signed under which Tube Investments, Ltd., and Stewarts and Lloyds, Ltd., undertake to co-operate in the scheme. Part of Palmer's works have been acquired, and all capital required is available, including the maximum from the Special Areas Reconstruction Association.

## Some Contracts

Messrs. Harland and Wolff, Ltd., Glasgow, have secured the contract for castings for the sister ship to the *Queen Mary*. They include gear cases, gear-wheel centres, turbine castings, etc., the major castings for the machinery. The order involves over 1,100 tons of castings and will be executed at the firm's Clyde foundry.

The English Steel Corporation, Ltd., Sheffield, has secured an important contract, valued at over £100,000, from Italy. The order involves the supply of forged steel high-pressure hydrogenation vessels. Other orders of a similar character have been placed for plants in this country and abroad, including those for Imperial Chemical Industries at Billingham. In order to facilitate the delivery of the requisite high-pressure plant Messrs. Thomas Firth and John Brown, Ltd., are co-operating in their production.

The Greenock Dockyard Co., Ltd., has received what is claimed to be the largest shipbuilding order placed in Greenock; it is an order for six 11,000-ton vessels for the Clan Line. The Company is already building five steamers for this shipping firm, and with this new order the yard will be fully employed for some years to come. The engines will be built by John G. Kincaid and Co., Ltd.

Twelve large monoplane air liners are being constructed for Imperial Airways by Sir W. G. Armstrong Whitworth Aircraft, Ltd., which are expected to establish new records for speed, combined with size and comfort. They are intended partly for use on Imperial Airways continental routes and partly for service on the trunk routes to the Empire. Their construction inaugurates the £2,000,000 development scheme recently announced by Imperial Airways. It is expected that the first of these new air liners will be put into service in the spring of next year.

## Large Trolley Bus Order

Karrier Motors, Ltd., have received from Huddersfield Corporation an order for 85 trolley-bus chassis of the E.6 type, the value of this order being approximately £100,000.

The new trolley buses are of the six-wheel double-deck type, with seating accommodation for 64 passengers, and they will be a notable addition to the Huddersfield fleet of trolley buses, which already includes 37 Karrier vehicles. Incidentally, it is the largest order for one make of trolley buses placed by any municipality since 1934, when Bournemouth Corporation ordered 103 Sunbeam B.T.H. six-wheel trolley buses.

The Karrier vehicles for Huddersfield will also be built in Wolverhampton, as both Sunbeam B.T.H. and Karrier trolley buses are manufactured by Sunbeam Commercial Vehicles, Ltd., Moorfield Works, Wollverhampton.

# MARKET PRICES

## ALUMINIUM.

| | |
|---|---|
| 98/99% Purity | £100 0 0 |

## ANTIMONY.

| | |
|---|---|
| English | £68 0 0 |
| Chinese | 52 0 0 |
| Crude | 25 10 0 |

## BRASS.

| | | |
|---|---|---|
| Solid Drawn Tubes | lb. | 10¼d. |
| Brazed Tubes | „ | 12¾d. |
| Rods Drawn | „ | 9¼d. |
| Wire | „ | 8½d. |
| *Extruded Brass Bars | „ | 5⅛d. |

## COPPER.

| | | |
|---|---|---|
| Standard Cash | | £43 11 3 |
| Electrolytic | | 48 10 0 |
| Best Selected | | 48 2 0 |
| Tough | | 47 15 0 |
| Sheets | | 78 0 0 |
| Wire Bars | | 49 10 0 |
| Ingot Bars | | 49 10 0 |
| Solid Drawn Tubes | lb. | 11½d. |
| Brazed Tubes | „ | 11¾d. |

## FERRO ALLOYS.

| | | |
|---|---|---|
| ‡Tungsten Metal Powder | lb. | 0 3 1¼ |
| ‡Ferro Tungsten | „ | 0 3 0 |
| Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up. | | |
| NOMINAL 2-4% Carbon, scale 11/- per unit | ton | 29 15 0 |
| 4-6% Carbon, scale 7/- per unit | „ | 22 7 6 |
| 6-8% Carbon, scale 7/- per unit | „ | 21 12 0 |
| 8-10% Carbon, scale 7/- per unit | „ | 21 12 0 |
| §Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit | „ | 33 0 0 |
| Guar. max. 1% Carbon, scale 12/6 per unit | „ | 36 0 0 |
| §Guar. max. 0·5% Carbon, scale 12/6 per unit | „ | 37 10 0 |
| ‡Manganese Metal 97-98% Mn. | lb. | 0 1 2 |
| ‡Metallic Chromium | „ | 0 2 5 |
| § Ferro-Vanadium 25-50% | „ | 0 12 8 |
| § Spiegel, 18-20% | ton | 7 10 0 |
| Ferro Silicon— | | |
| Basis 10%, scale 3/- per unit | ton | 6 5 0 |
| 20/30% basis 25%, scale 3/6 per unit | „ | 9 0 0 |
| 45/50% basis 45%, scale 5/- per unit | „ | 12 0 0 |
| 70/80% basis 75%, scale 7/- per unit | „ | 17 6 6 |
| 90/95% basis 90%, scale 10/- per unit | „ | 28 17 6 |
| § Silico Manganese 65/75% Mn., basis 65% Mn. | „ | 12 5 0 |
| § Ferro-Carbon Titanium, 15/18% Ti | lb. | 0 0 4½ |
| Ferro Phosphorus, 20-25% | ton | 22 0 0 |
| § Ferro-Molybdenum, Molyte | lb. | 0 4 6 |
| § Calcium Molybdate | „ | 0 4 2 |

## FUELS.

| | |
|---|---|
| Foundry Coke— | |
| S. Wales | £1 10 0 to 1 12 0 |
| Scotland | — 1 10 0 |
| Durham | 1 4 6 |
| Furnace Coke— | |
| Scotland | 1 5 0 to 1 6 0 |
| S. Wales | 1 5 6 to 1 6 0 |
| Durham | — 1 1 6 |

## GUN METAL.

| | |
|---|---|
| *Admiralty Gunmetal Ingots (88 : 10 : 2) | £68 0 0 |
| *Commercial Ingots | 49 10 0 |
| *Gunmetal Bars, Tank brand, 1 in. dia. and upwards .. lb. | 0 0 9 |
| *Cored Bars .. „ | 0 0 11 |

## MANUFACTURED IRON.

| | |
|---|---|
| Scotland— | |
| Crown Bars, Best | £10 10 0 |
| N.E. Coast— | |
| Rivets | 10 10 0 |
| Best Bars | 13 0 0 |
| Common Bars | 9 5 0 |
| Lancashire— | |
| Crown Bars | 10 10 0 |
| Hoops .. £10 10 0 to | 12 0 0 |
| Midlands— | |
| Crown Bars | 10 10 0 |
| Marked Bars | 13 0 0 |
| Unmarked Bars .. from | 9 7 0 |
| Nut and Bolt Bars .. £8 17 6 to | 9 7 6 |
| Gas Strip | 11 7 6 |
| S. Yorks— | |
| Best Bars | 10 15 0 |
| Hoops .. from | 11 7 6 |

## PHOSPHOR BRONZE.

| | | |
|---|---|---|
| *Bars, "Tank" brand, 1 in. dia. and upwards—Solid | lb. | 9d. |
| *Cored Bars | „ | 11d. |
| †Strip | „ | 11½d. |
| †Sheet to 10 W.G. | „ | 1/- |
| †Wire | „ | 1/0¾ |
| †Rods | „ | 11d |
| †Tubes | „ | 1/2¼ |
| †Castings | „ | 1/0½ |
| †10% Phos. Cop. £30 above B.S. | | |
| †15% Phos. Cop. £35 above B.S. | | |
| †Phos. Tin (5%) £30 above English Ingots. | | |

## PIG IRON.

| | |
|---|---|
| Scotland— | |
| Hematite M/Nos. | £4 5 6 |
| Foundry No. 1 | 4 1 6 |
| „ No. 3 | 3 19 0 |
| N.E. Coast— | |
| Hematite No. 1 | 4 5 6 |
| Foundry No. 1 | 4 1 6 |
| „ No. 3 | 3 19 0 |
| „ No. 4 | 3 14 0 |
| Silicon Iron | — |
| Forge | 3 14 0 |
| Midlands— | |
| N. Staffs Forge No. 4 | 3 17 0 |
| „ Foundry No. 3 | 4 3 0 |
| Northants— | |
| Foundry No. 1 | 4 3 0 |
| Forge No. 4 | 3 14 6 |
| Foundry No. 3 | 4 3 0 |
| Derbyshire Forge | 3 17 0 |
| „ Foundry No. 1 | 4 3 0 |
| „ Foundry No. 3 | 4 3 0 |
| West Coast Hematite | 4 11 0 |
| East „ „ | 4 5 6 |

## SWEDISH CHARCOAL IRON AND STEEL.

| | |
|---|---|
| Export pig-iron, maximum percentage of sulphur 0.015, of phosphorus 0.025. | |
| Per English ton | Kr. 115 |
| Billets, single welded, over 0.45 Carbon. | |
| Per metric ton | Kr. 265-335 |
| Per English ton | £13 17 6/£17 12 6 |
| Wire Rods, over 0.45 Carbon. | |
| Per metric ton | Kr.315-365 |
| Per English ton | £16 10 0/£19 2 6 |
| Rolled Martin iron, basis price. | |
| Per metric ton | Kr.210-230 |
| Per English ton | £11 0 0/£12 0 0 |
| Rolled charcoal iron, finished bars, basis price. | |
| Per metric ton | Kr.310 |
| Per English ton | £16 5 0 |

f.o.b. Gothenburg.

## SCRAP METAL.

| | |
|---|---|
| Copper Clean | £37 0 0 |
| „ Braziery | 34 0 0 |
| „ Wire | — |
| Brass | 23 0 0 |
| Gun Metal | 35 0 0 |
| Zinc | 9 10 0 |
| Aluminium Cuttings | 74 0 0 |
| Lead | 20 10 0 |
| Heavy Steel— | |
| S. Wales | 3 5 0 |
| Scotland | 2 17 6 |
| Cleveland | 3 0 0 |
| Cast Iron— | |
| Midlands | 2 15 0 |
| S. Wales | 2 14 0 |
| Cleveland | 3 5 0 |
| Steel Turnings— | |
| Cleveland | 2 5 0 |
| Midlands | 2 0 0 |
| Cast Iron Borings— | |
| Cleveland | 1 7 6 |
| Scotland | 1 18 0 |

## SPELTER.

| | |
|---|---|
| G.O.B. Official | — |
| Hard | £11 15 0 |
| English | 15 2 6 |
| India | 12 15 0 |
| Re-melted | 13 10 0 |

## STEEL.

| | |
|---|---|
| Ship, Bridge, and Tank Plates | |
| Scotland | £8 15 0 |
| North-East Coast | 8 15 0 |
| Midlands | 8 17 6 |
| Boiler Plates (Land), Scotland | 8 10 0 |
| „ „ (Marine) „ | — |
| „ „ (Land), N.E. Coast | 8 10 0 |
| „ „ (Marine) „ | 8 17 6 |
| Angles, Scotland | 8 7 6 |
| „ North-East Coast | 8 7 6 |
| „ Midlands | 8 7 6 |
| Joists | 8 15 0 |
| Heavy Rails | 8 10 0 |
| Fishplates | 12 10 0 |
| Light Rails .. £8 10 0 to | 8 15 0 |
| Sheffield— | |
| Siemens Acid Billets | 9 2 6 |
| Hard Basic .. £6 17 6 to | 7 2 6 |
| Medium Basic .. £6 12 6 and | 7 0 0 |
| Soft Basic | 5 10 0 |
| Hoops .. £9 10 0 to | 9 15 0 |
| Manchester | |
| Hoops .. £9 0 0 to | 10 0 0 |
| Scotland, Sheets 24 B.G. | 10 10 0 |

## HIGH SPEED TOOL STEEL.

| | | |
|---|---|---|
| Finished Bars 14% Tungsten | lb. | 2/- |
| Finished Bars 18% Tungsten | „ | 2/9 |
| Extras | | |
| Round and Squares, ½ in. to ¼ in. | „ | 3d. |
| Under ¼ in. to ⅛ in. | „ | 1/- |
| Round and Squares 3 in. | „ | 4d. |
| Flats under 1 in. × ¾ in. | „ | 3d. |
| „ „ ¼ in. × ¾ in. | „ | 1/- |

## TIN.

| | |
|---|---|
| Standard Cash | £232 0 0 |
| English | 232 10 0 |
| Australian | 232 0 0 |
| Eastern | 233 2 6 |
| Tin Plates I.C. 20 × 14 box | 18/9 |

## ZINC.

| | |
|---|---|
| English Sheets | £24 10 0 |
| Rods | 25 10 0 |
| Battery Plates | — |
| Boiler Plates | — |

## LEAD.

| | |
|---|---|
| Soft Foreign | £18 5 6 |
| English | 20 5 0 |

*McKechnie Brothers, Ltd. Nov. 12. † C. Clifford & Son, Ltd., Nov. 12. ‡ Murex Limited, Nov. 12

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, Nov. 12.